A COMPUTER PROGRAM FOR EVALUATING FORESTRY OPPORTUNITIES UNDER THREE INVESTMENT CRITERIA

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INTRODUCTION

Researchers have provided forest managers and their consultants with several computer programs for analyzing investments in forestry (Hall 1962, Row 1963, Schweitzer et al. 1967, and Forster 1968). These computer programs have been modified in many cases to apply to situations not originally envisioned by the program developers (e.g., see Marty et al. 1966, Green and Alley 1967, Wikstrom and Alley 1968). These programs are particularly useful if the situation being analyzed fits one of the options available in the program and if the manager's investment criterion is handled by the program. However, most of the available computer programs are designed for specific problems and, therefore, are relatively complex to use.[1/] In addition, only two investment criteria are available in the programs; namely, internal rate of return and present net worth.

This paper is meant to fulfill the following objectives. First, to announce the availability of the IVST computer program to prospective users. Second, to discuss the applicability of this program to managerial problems. Finally, to outline the operating characteristics of the program so analysts can use it.

PROBLEMS WHICH MAY BE ANALYZED WITH IVST

IVST, in common with all other investment analysis computer programs, is designed to help the decisionmaker decide whether or not to pursue certain productive activities or alternatives. There are many types of investment decisions, including: (1) whether a certain kind of productive activity should be pursued at all, (2) the intensity at which a productive enterprise should be operated, (3) timing of the productive activity in relation to other activities, (4) sequence of the productive activity in relation to other activities, (5) the location at which the productive activity takes place, and (6) the best way to accomplish the productive activity--i.e., technology. Depending upon the way the alternatives are formulated, any decision may be included in an IVST analysis.

The type of decision to be analyzed dictates the kinds of data which are required. Here it is presumed that data will be expressed in economic units, e.g., dollars. Data will consist, therefore, of costs and returns tagged with a time dimension--date of occurrence. Realistically, the costs and returns must be regarded as managerial expectations, since an investment analysis of historical occurrences provides few guidelines to the future.

However, data alone are not sufficient to guide managers in their decision-making function. Also required is a decision rule or criterion, which simply stated is the manager's systematic way of evaluating how well alternative strategies provide for fulfilling the firm's goals.

Now, whereas the type of investment is completely open when IVST is used, the choice of criterion is not. Three alternative investment criteria are available in IVST: internal rate of return, present net worth, and benefit-cost

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[1/] The rate-of-return computer programs devised by Hall (1962) and Forster (1968) are exceptions, since they are general and presume no particular problem context.

ratio.[2] It is the job of the manager to choose the criterion which will best provide for fulfillment of the firm's goals. If one of the three criteria available in IVST will fill this bill, then this computer program will be useful to the manager. On the other hand, if the manager selects an investment criterion that is not available in IVST, then the program will not be useful and, indeed, its use would be harmful, since misallocated resources would result.

IVST is a generalized computer program in that no particular problem context is presumed by its structure and output formats. The program is simple to use in that input requirements are minimal for the types of problems which may be analyzed. It is assumed that all preliminary data preparation is handled externally. Input data consist of a time-tagged stream of costs and returns and certain identifying information. A data preparation computer program will be required if data are in the form of quantities and prices. Large problems may be analyzed since data storage requirements are low per alternative analyzed. Finally, as pointed out above, IVST permits the analyst to select for examination one or more of three optional investment criteria: present net worth, internal rate of return, and the benefit-cost ratio. In addition, the structure of IVST is such as to permit other criteria subroutines to be added if desired by the analyst.

IVST was derived from two computer programs developed to analyze data for the Douglas-fir Supply Study, a cooperative study by the Pacific Northwest Region, Forest Service, and this Station. One of the computer programs was based on the internal rate-of-return criterion, the other on the present net worth and benefit-cost ratio criteria. These computer programs were modified to become options within IVST.

STRUCTURE OF IVST

IVST consists of a main program and two subroutines. The main program reads all data and provides for the printing of the first report, which consists of the input data. Subroutine BCA calculates the benefit-cost ratio and present net worth for the range of interest rates selected by the user. Subroutine IROR calculates the internal rate of return.[3] All results of the analyses are printed under control of the subroutines. Either BCA and/or IROR may be selected for any problem by the analyst.

Both BCA and IROR are closed or linked subroutines, i.e., a subroutine not stored in the path of the main routine, IVST. A closed subroutine is entered by a jump operation in the main routine and return to the main routine is provided at the end of the operation. Because of this configuration, it is possible to

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[2] The reader interested in the theoretical aspects of these economic criteria should consult Eckstein (1958, pp. 70-79) on the benefit-cost ratio, and Hirshleifer (1958, pp. 329-352) on the internal rate of return and present net worth criteria. A comparison of management guides developed by application of these criteria to a forestry problem may be found in Webster (1965).

[3] Development of IROR began with a major modification of Row's rate-of-return program (Row 1963). The author wishes to acknowledge the programing assistance of Edgel E. Skinner of the Station's statistical and data processing services staff in this initial effort.

make use of the subroutines independently of the main routine. That is, the prospective user may design his own main routine and simply call either BCA and/or IROR when needed. It may be desirable to do this when input data are not in proper form for the present main routine. Prospective users are urged to consult a computer programer if the coding of a new main routine appears necessary.

If the user wishes output for all three criteria options, then a total of four reports will be printed. As noted above, the first report consists of the input data. In the second report, the benefit-cost ratio and present net worth for every interest rate within the selected range will be listed for each alternative. The third report consists of certain messages generated within the IROR subroutine that will assist the analyst in interpreting results of the internal rate-of-return analysis. Finally, the fourth report lists present net worth for each interest rate within the selected range for each alternative until the internal rate of return is found. The internal rate of return is listed as the last interest rate for each alternative. After the last report is printed, control is switched back from the subroutines to the main routine and an end-of-problem card is read. At that time, the user can either terminate the program or solve another problem.

The Main Program IVST

Function

The function of the main program is to read a stream of periodic annual costs, a stream of periodic annual returns, and associated data; prepare a report of the input data; generate annual costs and annual returns if data are for a period other than 1 year; and call in the criteria subroutines desired by the user. IVST is designed to accept periodic annual data for whatever period length the user desires. However, the same length period must apply to each cost and return entered for that particular problem. Of course, if period length differs from one alternative to another, each alternative may be run as a separate problem. If period length varies within an alternative, however, it is mandatory that period length be set at 1 year and that annual data be read.

The advantages of having the capability of reading periodic annual costs and returns, as opposed to annual inputs, include savings of time, card costs, keypunching costs, the minimization of input error, and convenience.

IVST permits initial costs and returns to be read when a period length of 1 year is designated. Initial costs and returns are those costs and returns that occur in year zero of the investment series.

IVST Inputs

There are 17 specific types of inputs to the IVST program. Formats of input cards are shown in table 1 of the Appendix. The inputs are:

1. Alphanumeric study identification.

2. Beginning interest rate of the range to be examined, decimal.

3. Final or ending interest rate of the range to be examined, decimal.

4. Increment in interest rate, decimal.

5. Number of alternatives in problem.

6. Indicator of an initial cost or return (i.e., a cost or return occurring in year 0). If initial costs and returns are used, then period length must be 1 year (i.e., annual data must be read).

7. Alphanumeric identification of alternatives.

8. Problem number.

9. Series type indicator (either terminable or perpetual).

10. Investment criterion indicator (either internal rate of return or benefit-cost ratio and present net worth, or all three).

11. Length of period over which periodic costs and returns apply, years. Annual data may be read by setting period length equal to 1.

12. Maximum number of years in any alternative, i.e., length of longest investment series of any alternative in the problem.

13. Number of years in each alternative.

14. Alphanumeric problem identification.

15. Periodic annual costs for each alternative, dollars.

16. Periodic annual returns for each alternative, dollars.

17. End of problem indicator.

IVST Main Program Outputs

Input items 1, 7, 8, 9, 11, 14, 15, and 16 constitute the first report of IVST (see fig. 1). Data for five alternatives are printed on each page.

INVESTMENT ANALYSIS-- RESEARCH PAPER SAMPLE PROBLEM

PROBLEM NO. 1 TEST DATA

TERMINABLE SERIES PERIOD= 5 YEARS

	MANAGEMENT ALTERNATIVE									
	ONE		TWO		THREE		FOUR		FIVE	
PERIOD	ANNUAL COST	ANNUAL RETURN	ANNUAL COST	ANNUAL RETURN	ANNUAL COST	ANNUAL RETURN	ANNUAL COST	ANNUAL RETURN	ANNUAL COST	ANNUAL RETURN
1	15	12	2266425	104294	32	34	33	91	65	12
2	23	65	2293800	29337	45	52	22	92	21	23
3	65	42	1279570	-74550	89	12	44	93	45	52
4	34	83	-2186855	1562249	78	65	55	94	23	45
5	0	0	-2214230	1584476	52	89	66	95	57	78
6	0	0	-2031094	1607694	14	35	88	96	84	65
7	0	0	0	0	65	67	77	97	52	98
8	0	0	0	0	23	85	22	98	11	63
9	0	0	0	0	15	64	11	31	32	65
10	0	0	0	0	24	13	22	32	11	32
11	0	0	0	0	57	25	44	34	44	12
12	0	0	0	0	62	35	66	35	55	45
13	0	0	0	0	54	53	88	36	22	78
14	0	0	0	0	13	92	99	37	33	96
15	0	0	0	0	52	45	33	38	65	32
16	0	0	0	0	0	0	55	39	47	58
17	0	0	0	0	0	0	45	32	0	0
18	0	0	0	0	0	0	23	45	0	0
19	0	0	0	0	0	0	15	68	0	0
20	0	0	0	0	0	0	72	28	0	0

Figure 1.--*First report of the IVST computer program showing input data.*

Subroutine BCA

Function

The function of subroutine BCA is to calculate present net worth and benefit-cost ratio for each alternative for the range of interest rates selected by the analyst.

Criterion

Present net worth of a terminable series of costs and returns (dollars) is:

$$PNW_n = \sum_{t=o}^{n} \frac{R_t}{(1+i)^t} - \sum_{t=o}^{n} \frac{C_t}{(1+i)^t} \qquad (1)$$

where

C_t = cost in year t, dollars[4/]

R_t = return or benefit in year t, dollars[4/]

i = discount rate, decimal

n = number of years in the investment series

Present net worth of a perpetual series of costs and returns is:

$$PNW_p = PNW_n \cdot \frac{(1+i)^n}{(1+i)^n - 1} \qquad (2)$$

In contrast, the benefit-cost ratio is:

$$\frac{B}{C} = \frac{\sum_{t=o}^{n} R_t / (1+i)^t}{\sum_{t=o}^{n} C_t / (1+i)^t} \qquad (3)$$

Equation 3 can be used for both terminable and perpetual series because the infinite series multiplier (the last term in equation 2) cancels out of equation 3.

Subroutine BCA does not assume that discounted returns (or benefits) or discounted costs are positive. It is likely that both negative returns and negative costs will occur if the analyst is working with marginal values (i.e., differences from some base).

[4/] Any asset salvage values (revenues) or replacement costs should be included in the last term of the series.

Four conditions are possible:

Condition	Return (or benefit)	Cost
1	+	+
2	-	+
3	+	-
4	-	-

Since the benefit-cost ratio must always be positive, it was necessary to include rules for conditions 2, 3, and 4 within the BCA subroutine. In conditions 2 and 3, the B/C is set equal to zero. In condition 2, the reasoning is that a negative return is equivalent to a positive cost, but returns are equal to zero, hence B/C = 0/+ = 0. Likewise, in condition 3 a negative cost is equivalent to a positive return, hence cost is equal to zero. Therefore, B/C = +/0, which is undefined. These two conditions can be easily discerned since condition 2 will always be associated with a negative present net worth, whereas present net worth will always be positive in the case of condition 3.

In condition 4, negative returns are equivalent to positive costs and negative costs are equivalent to positive returns, hence the benefit-cost ratio is set equal to its inverse, the ratio of costs to benefits (C/B).

In addition, it is possible that either discounted costs or discounted returns are equal to zero. In such a case, the BCA subroutine will set B/C equal to zero.

BCA Outputs

Subroutine BCA provides for printing the present net worth and benefit-cost ratio for each alternative for the entire range in interest rates, together with identification (see fig. 2).[5/] Results for five alternatives are printed on each page. After results are printed for all alternatives, control is returned to the main program.

Subroutine IROR

Function

The function of subroutine IROR is to calculate the internal rate of return for each alternative within a range of starting interest rates selected by the user, using the annual costs and annual returns generated by the IVST main program.

5/ The discounted costs and discounted returns may also be printed if the user so desires. The slight modification of the BCA subroutine which will provide this output is described in the Appendix, page 17.

BENEFIT-COST ANALYSIS-- RESEARCH PAPER SAMPLE PROBLEM

PROBLEM NO. 1 TEST DATA

BENEFIT-COST RATIO (B/C) AT ALTERNATIVE RATES OF INTEREST
PRESENT NET WORTH (PNW) AT ALTERNATIVE RATES OF INTEREST

	MANAGEMENT ALTERNATIVE									
	ONE		TWO		THREE		FOUR		FIVE	
RATE	*PNW	B/C*	*PNW	B/C*	*PNW	B/C*	*PNW	B/C*	*PNW	B/C*
0.	0.3250E 03	1.47	0.2703E 08	0.	0.4550E 03	1.13	0.1155E 04	1.24	0.9350E 03	1.28
0.50	0.3032E 03	1.47	0.2202E 08	0.	0.3284E 03	1.12	0.1171E 04	1.31	0.7102E 03	1.26
1.00	0.2832E 03	1.47	0.1765E 08	12.19	0.2322E 03	1.10	0.1159E 04	1.38	0.5356E 03	1.23
1.50	0.2648E 03	1.46	0.1385E 08	5.11	0.1588E 03	1.08	0.1130E 04	1.45	0.3991E 03	1.20
2.00	0.2478E 03	1.46	0.1054E 08	3.15	0.1026E 03	1.06	0.1090E 04	1.53	0.2915E 03	1.17
2.50	0.2322E 03	1.46	0.7657E 07	2.23	0.5956E 02	1.04	0.1045E 04	1.61	0.2063E 03	1.14
3.00	0.2178E 03	1.45	0.5150E 07	1.70	0.2650E 02	1.02	0.9984E 03	1.68	0.1383E 03	1.11
3.50	0.2046E 03	1.45	0.2971E 07	1.36	0.1186E 01	1.00	0.9510E 03	1.75	0.8375E 02	1.07
4.00	0.1923E 03	1.45	0.1078E 07	1.12	-0.1810E 02	0.98	0.9048E 03	1.81	0.3972E 02	1.04
4.50	0.1809E 03	1.44	-0.5625E 06	0.94	-0.3268E 02	0.97	0.8605E 03	1.88	0.4019E 01	1.00
5.00	0.1704E 03	1.44	-0.1983E 07	0.81	-0.4355E 02	0.95	0.8184E 03	1.93	-0.2506E 02	0.97
5.50	0.1606E 03	1.44	-0.3211E 07	0.70	-0.5152E 02	0.94	0.7789E 03	1.99	-0.4884E 02	0.94
6.00	0.1516E 03	1.44	-0.4270E 07	0.61	-0.5717E 02	0.93	0.7419E 03	2.04	-0.6835E 02	0.91
6.50	0.1432E 03	1.43	-0.5181E 07	0.54	-0.6101E 02	0.92	0.7075E 03	2.09	-0.8439E 02	0.88
7.00	0.1354E 03	1.43	-0.5962E 07	0.48	-0.6339E 02	0.91	0.6754E 03	2.14	-0.9761E 02	0.85
7.50	0.1281E 03	1.43	-0.6629E 07	0.43	-0.6464E 02	0.90	0.6457E 03	2.18	-0.1085E 03	0.82
8.00	0.1213E 03	1.42	-0.7196E 07	0.39	-0.6499E 02	0.89	0.6180E 03	2.22	-0.1175E 03	0.79
8.50	0.1150E 03	1.42	-0.7675E 07	0.35	-0.6463E 02	0.89	0.5923E 03	2.26	-0.1249E 03	0.77
9.00	0.1090E 03	1.42	-0.8078E 07	0.32	-0.6373E 02	0.88	0.5685E 03	2.29	-0.1310E 03	0.74
9.50	0.1035E 03	1.42	-0.8413E 07	0.30	-0.6241E 02	0.88	0.5462E 03	2.33	-0.1360E 03	0.72
10.00	0.9834E 02	1.42	-0.8685E 07	0.27	-0.6076E 02	0.88	0.5255E 03	2.36	-0.1401E 03	0.70

Figure 2.--*Second report of the IVST computer program showing results of use of the present net worth and benefit-cost ratio criteria.*

Criterion

The internal rate of return (i) is defined as that interest rate which equates discounted returns to discounted costs, i.e., the rate that results in a present net worth of zero. If we use the same notation as above, then the internal rate of return is defined as i when the following condition is satisfied:

$$\sum_{t=o}^{n} \frac{R_t}{(1+i)^t} = \sum_{t=o}^{n} \frac{C_t}{(1+i)^t} \quad \text{for a terminable series} \tag{4}$$

or

$$\left[\sum_{t=o}^{n} \frac{R_t}{(1+i)^t}\right] \cdot \left[\frac{(1+i)^n}{(1+i)^n - 1}\right] = \left[\sum_{t=o}^{n} \frac{C_t}{(1+i)^t}\right] \cdot \left[\frac{(1+i)^n}{(1+i)^n - 1}\right] \tag{5}$$

for a perpetual series.

It should be noted that infinite series multiplier $\left[\frac{(1+i)^n}{(1+i)^n - 1}\right]$ cancels in equation 5, leaving it equivalent to equation 4. Therefore, the internal rate of return for a perpetual series is identical to the internal rate for a terminable series. However, discounted costs and returns will not be identical for both series.

At this point it may be helpful to indicate how the three investment criteria relate to one another. When the discount rate is equal to the internal rate and hence discounted costs are equal to discounted returns (present net worth is equal to zero), then the benefit-cost ratio is one (compare equations 1, 3, and 4).

Except for Forster's program (1968), all of the rate-of-return computer programs cited earlier use unmodified iteration to isolate the internal rate of return. In contrast, in IVST present net worth is iterated at interest rate intervals selected by the analyst until a change of sign is found. At that point,

the bisection method is applied until the internal rate of return is found within the interval at which the sign change occurs.[6/] [7/]

The power of this technique can best be realized by selecting a wide range of interest rates and a large value for the rate increment. In this way, convergence to the internal rate of return occurs quickly as large bisection intervals are used.

However, if one desires to calculate present net worth and the benefit-cost ratio as well as internal rate of return, the advantage of selecting a wide range of interest rates and a large value for the rate increment may be lost. The analyst will generally wish to use the BCA subroutine with a small value for the rate increment. This in turn may necessitate investigating a narrow range of interest rates (see program limitation 8, page 14). Because interest rates to be used in both subroutines are determined in the main program, they must represent a compromise if the two subroutines are to be used together. Therefore, in cases such as this, the analyst may prefer to use the subroutines sequentially. This can be accomplished by setting up two problems for a single computer run, both with identical data except for interest rate range and increment. One of the problems would be run with the IROR subroutine with a wide range of interest rates and large increment, and the other problem would be run with the BCA subroutine with a narrow range of interest rates and a small increment.

An example which illustrates the bisection method utilized in IROR is shown in figure 3. In this example a range of interest rates of 0 to 10 percent at increments of 5 percent were specified. The program calculated the present net worth (PNW) at a rate of 0 percent and found it to be $455. Next PNW was calculated at 5 percent and found to be -$43. At this point, the change in sign initiates the bisection procedure. The program calculates PNW halfway between 0 percent and 5 percent, that is at 2.50 percent. Here PNW is positive ($60), so the program tries the rate midway between 2.50 percent and 5 percent, or 3.75 percent. PNW at that rate is negative (-$9), so it is apparent that the internal rate lies between 2.50 percent and 3.75 percent. This procedure is continued until the internal rate of return is found at 3.52 percent on the sixth bisection (see fig. 3).

IROR Outputs

Three types of messages may be generated prior to the printing of tables showing the internal rate of return (see fig. 4).

[6/] For a discussion of the use of the bisection method for finding a real zero, see Hamming (1962, p. 352). The bisection method can result in both decreased computation time and increased accuracy. As Hamming points out, "Since each step halves the interval in which the zero lies, ten steps will reduce the interval by a factor of about 1,000; 20 steps, 1,000,000; etc. Thus the method, which assumes *only* continuity and the ability to evaluate the function at any point, is fairly effective."

[7/] The recent rate-of-return computer program developed by Forster (1968) also utilizes the bisection method, which he terms "interval halving."

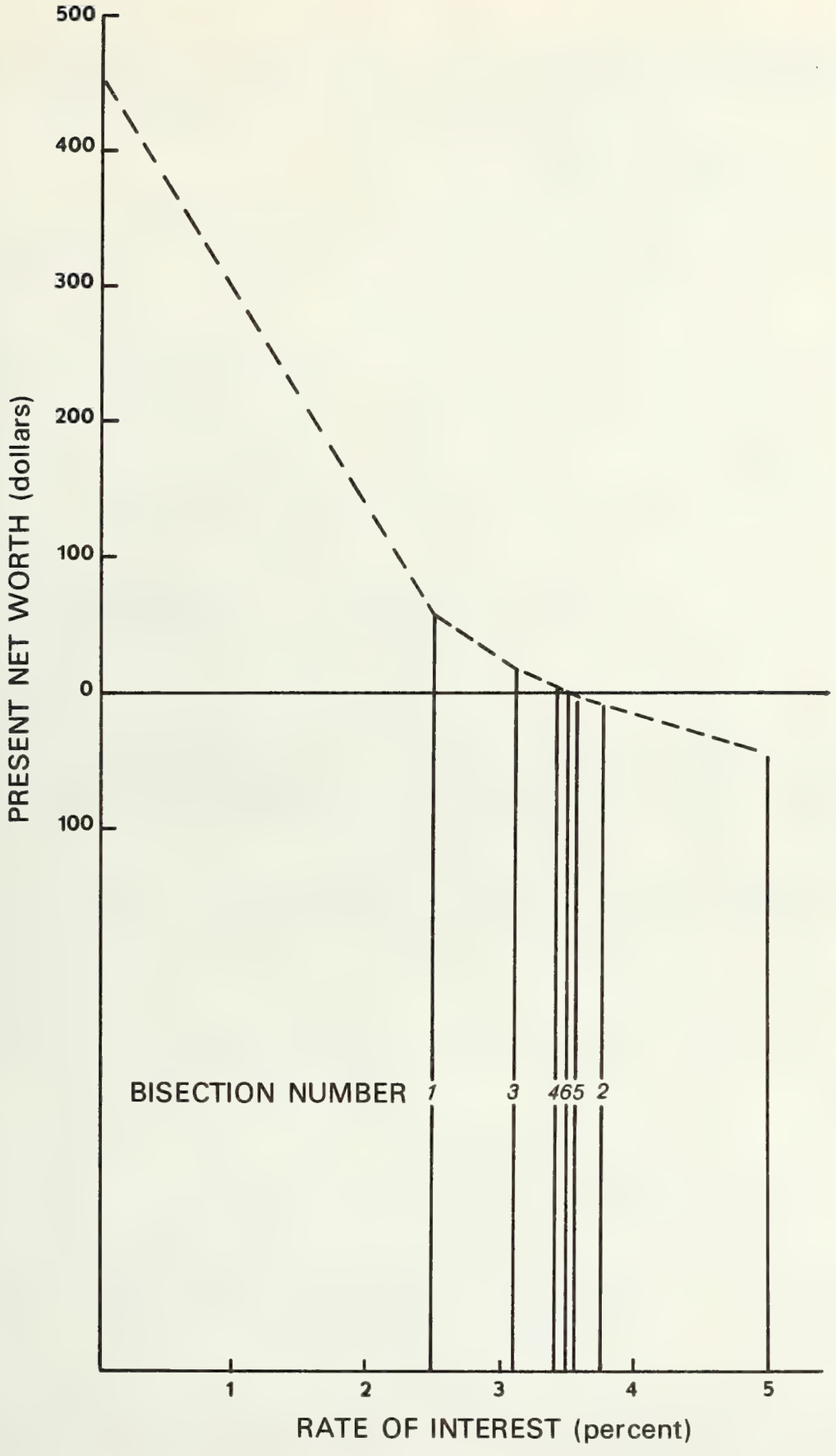

Figure 3.--*An example of how the IROR subroutine converges to the internal rate of return.*

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                DETERMINING RATE OF RETURN--      RESEARCH PAPER SAMPLE PROBLEM

PROBLEM NO.  1      TEST DATA

                                        MESSAGES

     INTERNAL RATE OF RETURN DOES NOT FALL WITHIN SELECTED RANGE FOR ALTERNATIVE   1

     BISECTION LIMIT EXCEEDED IN ALTERNATIVE   TWO
     CALCULATED PRESENT NET WORTH DOES NOT FALL BETWEEN PLUS AND MINUS   1.00 DOLLARS

     PNW AS A FUNCTION OF INTEREST RATE IS NOT TENDING TOWARD ZERO WITHIN A PORTION OF ITS RANGE FOR ALTERNATIVE   4
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Figure 4.--*Third report of the IVST computer program indicating messages generated by the IROR subroutine.*

If the internal rate of return is not found within the range of interest rates selected by the analyst, the message

> INTERNAL RATE OF RETURN DOES NOT FALL WITHIN SELECTED RANGE FOR ALTERNATIVE X

will be generated, with the alternative number filled in in place of X.

The second message that may be generated informs the user of the precision levels that apply to the internal rates of return. Precision level is indicated only when bisection is used. If the internal rate is found on iteration, a zero will appear in the PNW column and the precision level is to the nearest $0.01.

Three precision levels are built into the bisection phase of the IROR subroutine, $1, $10, and $100 (i.e., rate-of-return equation identity may be correct either to the nearest $1, $10, or $100). Up to 100 bisections may occur within each of these precision levels. Whenever an internal rate fails to be determined at one of these precision levels, a message is generated and the next lower level of precision is tried. The message is of the form

> BISECTION LIMIT EXCEEDED IN ALTERNATIVE X. CALCULATED PRESENT NET WORTH DOES NOT FALL BETWEEN PLUS AND MINUS Y DOLLARS

with the alternative number filled in by IROR in place of X, and the precision level in place of Y.

A third message will be generated whenever present net worth as a function of interest rate does not converge toward zero. In this case, the form of the message is

> PNW AS A FUNCTION OF INTEREST RATE IS NOT TENDING TOWARD ZERO WITHIN A PORTION OF ITS RANGE FOR ALTERNATIVE X

Occurrence of this message does not necessarily mean that the internal rate of return does not fall within the range of interest rates selected by the user. However, IROR will discontinue searching for the internal rate whenever the above condition is encountered. When this condition occurs, the analyst is advised to use the BCA subroutine to generate sufficient points to indicate the form of the present net worth function. If the above condition is caused by portions of the function which are not monotonic, it is likely that the interest rate range can be modified so as to exclude such portions, thereby permitting IROR to converge to the internal rate of return.

The behavior of IROR in various situations is illustrated in figure 5, wherein 10 representative types of present net worth functions are depicted.[8/] The types shown in figure 5 by no means exhaust the possibilities. In each graph, present net worth (dollars) is plotted over the range of interest rates selected for examination. IROR will treat each type of function as follows:

Type 1.--Present net worth is a monotonic decreasing function of interest rate. The internal rate of return falls within the range selected and will be determined by IROR.

Type 2.--Present net worth is a monotonic increasing function of interest rate. The internal rate of return falls within the range selected and will be determined by IROR.

Type 3.--Present net worth is a monotonic decreasing function of interest rate. However, the internal rate of return is located outside the range selected.

Type 4.--Present net worth is a monotonic increasing function of interest rate. However, the internal rate of return is located outside the range selected.

In the case of types 3 and 4, IROR will calculate present net worth for the full range of interest rates and then generate the message

> INTERNAL RATE OF RETURN DOES NOT FALL WITHIN SELECTED RANGE FOR ALTERNATIVE X

Type 5.--Present net worth is a monotonic decreasing function of interest rate. The internal rate of return is located outside the range selected, and present net worth is not converging toward zero as interest rate increases.

Type 6.--Present net worth is a monotonic increasing function of interest rate. The internal rate of return is located outside the range selected, and present net worth is not converging toward zero as interest rate increases.

In the case of types 5 and 6, IROR will calculate two iterated points along that segment and then print the message

> PNW AS A FUNCTION OF INTEREST RATE IS NOT TENDING TOWARD ZERO WITHIN A PORTION OF ITS RANGE FOR ALTERNATIVE X

Types 7 and 8.--Present net worth is not a monotonic function of interest rate. Although the internal rate of return lies within the range of rates selected, IROR will not determine it. Rather, these situations will be handled by IROR exactly as types 5 and 6. If these types of functions are suspected, the analyst should examine PNW over a wide range of interest rates by use of BCA subroutine. After examining BCA outputs, it is possible to reset the range in interest rates to avoid the program stop, thereby permitting the IROR subroutine to converge to the internal rate of return. Also, it should be pointed out that

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[8/] Samuelson (1937, p. 475) indicates that some investment opportunities may have no real internal rate of return (i.e., the present net worth equation has only imaginary roots). Also, he mentions the possibility of multiple internal rates, i.e., the present net worth function may equal zero at many interest rates.

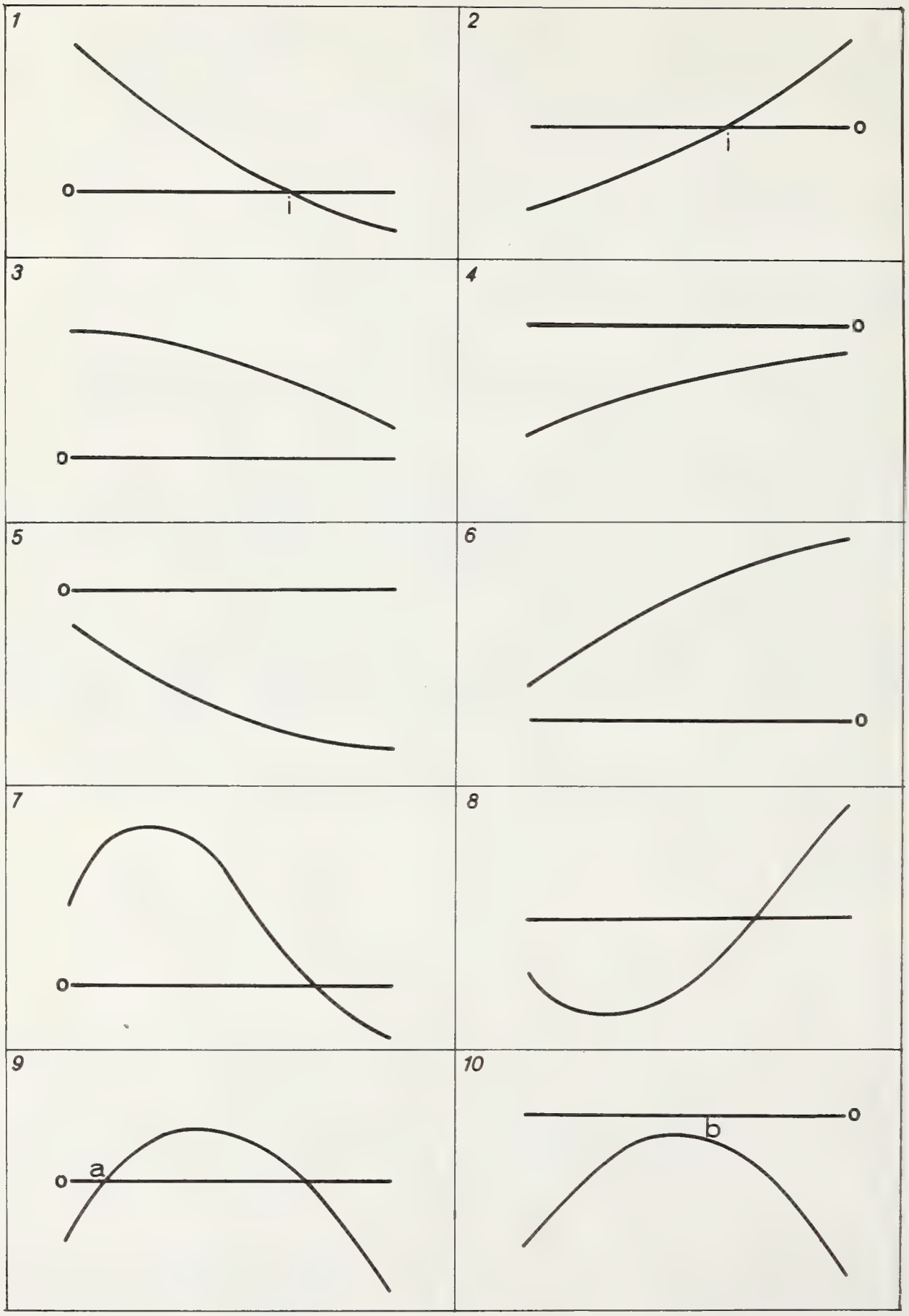

Figure 5.--*Representative types of present net worth functions.*

if the analyst initially sets the interest rate increment large enough, the program stop may be avoided and convergence will occur.

Type 9.--Present net worth is zero at two interest rates. IROR will locate only point a.

Type 10.--Points will be iterated until point b is reached, at which time the following message is printed and the program proceeds to the next alternative.

> PNW AS A FUNCTION OF INTEREST RATE IS NOT TENDING TOWARD ZERO
> WITHIN A PORTION OF ITS RANGE FOR ALTERNATIVE X

The final output is a table listing interest rates and present net worths for each alternative until the internal rate of return is reached (see fig. 6). When the internal rate of return is found, the precision level applicable to that rate is indicated in the present net worth (PNW) column.

DETERMINING RATE OF RETURN-- RESEARCH PAPER SAMPLE PROBLEM

PROBLEM NO. 1 TEST DATA

PRESENT NET WORTH (PNW) AT ALTERNATIVE RATES OF INTEREST

MANAGEMENT ALTERNATIVE

ONE		TWO		THREE		FOUR		FIVE	
* RATE	PNW *	* RATE	PNW *	* RATE	PNW *	* RATE	PNW *	* RATE	PNW *
0.	3.2500E 02	0.	2.7029E 07	0.	4.5500E 02	0.	1.1550E 03	0.	9.3500E 02
0.50	3.0320E 02	0.50	2.2019E 07	0.50	3.2838E 02	0.50	1.1709E 03	0.50	7.1018E 02
1.00	2.8318E 02	1.00	1.7654E 07	1.00	2.3221E 02	0.	0.	1.00	5.3560E 02
1.50	2.6477E 02	1.50	1.3851E 07	1.50	1.5883E 02	0.	0.	1.50	3.9906E 02
2.00	2.4784E 02	2.00	1.0539E 07	2.00	1.0265E 02	0.	0.	2.00	2.9154E 02
2.50	2.3223E 02	2.50	7.6571E 06	2.50	5.9556E 01	0.	0.	2.50	2.0631E 02
3.00	2.1784E 02	3.00	5.1499E 06	3.00	2.6496E 01	0.	0.	3.00	1.3831E 02
3.50	2.0456E 02	3.50	2.9706E 06	3.50	1.1855E 00	0.	0.	3.50	8.3747E 01
4.00	1.9228E 02	4.00	1.0784E 06	3.53	1.0000E 00	0.	0.	4.00	3.9720E 01
4.50	1.8092E 02	4.32	1.0000E 01	0.	0.	0.	0.	4.50	4.0187E 00
5.00	1.7040E 02	0.	0.	0.	0.	0.	0.	4.56	1.0000E 00
5.50	1.6065E 02	0.	0.	0.	0.	0.	0.	0.	0.
6.00	1.5159E 02	0.	0.	0.	0.	0.	0.	0.	0.
6.50	1.4318E 02	0.	0.	0.	0.	0.	0.	0.	0.
7.00	1.3536E 02	0.	0.	0.	0.	0.	0.	0.	0.
7.50	1.2808E 02	0.	0.	0.	0.	0.	0.	0.	0.
8.00	1.2129E 02	0.	0.	0.	0.	0.	0.	0.	0.
8.50	1.1496E 02	0.	0.	0.	0.	0.	0.	0.	0.
9.00	1.0904E 02	0.	0.	0.	0.	0.	0.	0.	0.
9.50	1.0351E 02	0.	0.	0.	0.	0.	0.	0.	0.
10.00	9.8338E 01	0.	0.	0.	0.	0.	0.	0.	0.

END OF RUN

Figure 6.--*Fourth report of the IVST computer program showing results of use of the internal rate-of-return criterion.*

LIMITATIONS OF IVST

There are several limitations which must be observed in the use of IVST:

1. The number of alternatives analyzed within a problem must be less than or equal to 20.

2. The type of series (either terminable or perpetual) must be the same for all alternatives within a problem.

3. The number of years in the investment series for any alternative must be equal to or less than 140.

4. The length of period to which periodic annual costs or returns apply must be identical for all alternatives within a given problem. However, the number of periods may vary from one alternative to another. The number of years in each alternative (i.e., the investment series length in years) is therefore equal to the product of number of periods and period length.

5. The range and increment in interest rate must be identical for all alternatives within a given problem.

6. The beginning interest rate must be greater than -100 percent.

7. The ending interest rate must be less than 85 percent if the investment series length for any alternative in the problem is 140 years. Higher interest rates may be analyzed if the maximum investment series length decreases. Users should consult with computing center personnel regarding the limits on the exponential function subroutine being used, as this is the factor that limits the range of interest rates which may be analyzed.

8. The interest rate range and increment selected by the user must not result in more than 200 interest rates being generated. However, more than 200 interest rates may be generated during the bisection procedure, which is not under the user's control but is automatically controlled by the IROR subroutine.

9. An attempt to analyze a zero interest rate for a perpetual series will result in the program skipping that rate and passing on to the next interest rate within the range selected by the user. No program stop or computational error will result.

OPERATION OF IVST

Input card formats, program flow charts, and a listing of the IVST source program are included in the Appendix. IVST is coded in FORTRAN IV and is operable on either the IBM 7040 or the IBM 360/50 (both time-sharing and nontime-sharing modes) computing systems. Slight modification may be necessary before IVST can be used with other systems. A total of 31,988 words of core storage are required on the IBM 7040 computer for this program. Use of IVST on computers with smaller memory capacities will require modification of the program. The sample problem shown in this paper required 1 minute and 4 seconds of execution time on the IBM 7040.

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APPENDIX

Preparation of IVST Input Cards

There are nine types of input cards required by the IVST program. The format of these input cards is indicated in table 1. Card columns for which no punch is indicated should be left blank. All data except alphanumeric must be right-justified (i.e., the units position must be at the extreme right of the field). It should be pointed out that input card types 1-6 and 9 contain identification and control data, whereas input card types 7 (periodic annual costs) and 8 (periodic annual returns) are sets of data applicable to independent alternatives. All costs are read for a given alternative. Then all returns are read for that same alternative. This sequence (i.e., all costs and then all returns for each alternative) is repeated until all alternatives have been read before the next input card type is read. The last card contains the end-of-problem indicator (MEND).

BCA Optional Output

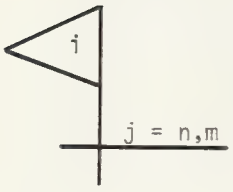
The discounted returns and discounted costs at each interest rate may be printed if the user desires. The only modification required in the BCA subroutine to provide for this output is to reproduce BCA program cards BCA 0370 and BCA 0375 (see listing of the BCA subroutine) deleting the "C" in the first column.

Table 1.-- IVST Program Input Format

Input card type	Program code	Item	Form	Card columns
1	STD(I)	Alphanumeric study identification.	A.....A	1-72
2	BRATE	Beginning interest rate, decimal.	X.XX	7-10
2	FRATE	Final interest rate, decimal.	X.XX	17-20
2	DELTA	Interest rate increment, decimal.	X.XX	27-30
2	LX	Number of alternatives in problem.	XX	34-35
2	INIT	Indicator of an initial cost or return; = 0, if there is an initial cost or return, = 1, if not.	X	40
3	LI(I,L)	Alphanumeric identification of alternative L. A second card is needed to handle over 10 alternatives.	AAAAAAAA	1-8, 9-16, ..., 73-80
4	NO	Problem number.	XXXX	1-4
4	NZ	Type of calculation; = 01, if series is perpetual, = 02, if series is terminable.	XX	7-8
4	IC	Investment criterion; = 01, internal rate of return, = 02, benefit/cost and present net worth, = 03, all three criteria.	XX	11-12
4	IP	Length of period, years.	XX	15-16
4	KCXX	Maximum number of years in the investment series of any alternative. If initial costs and returns are read, present year should be included in KCXX.	XXX	18-20
5	KCX(L)	Number of years in the investment series of each alternative L. If initial costs and returns are read, present year should be included in KCX(L).	XXX	1-3, 4-6, ..., 58-60
6	A(I)	Alphanumeric problem identification.	A.....A	1-72
7	COST(L,KC)	Periodic annual cost of alternative L, for period KC, dollars. ~~A second card is needed to handle 9-16 alternatives. A third card is needed to handle 17-20 alternatives.~~ Additional cards are required to read data for more than 8 periods.	XXXXXXXXXX	1-10, 11-20, ..., 71-80
8	REV(L,KC)	Periodic annual return of alternative L for period KC, dollars. ~~A second card is needed to handle 9-16 alternatives. A third card is needed to handle 17-20 alternatives.~~ Additional cards are required to read data for more than 8 periods.	XXXXXXXXXX	1-10, 11-20, ..., 71-80
9	MEND	Terminal card code; = 98, to do another problem. = 99, end-of-run.	XX	2-3

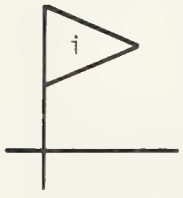
FLOW CHART FOR MAIN ROUTINE IVST

LEGEND FOR FLOW CHARTS

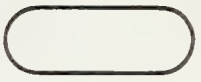


START OF DO LOOP i
INDEX j, LIMITS n,m.

SUBROUTINE
CALL OR RETURN



TERMINUS OF LOOP i



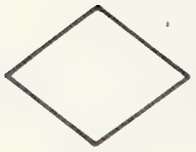
PROGRAM
BEGINNING AND END

COMPUTATION
OR PROCESSING

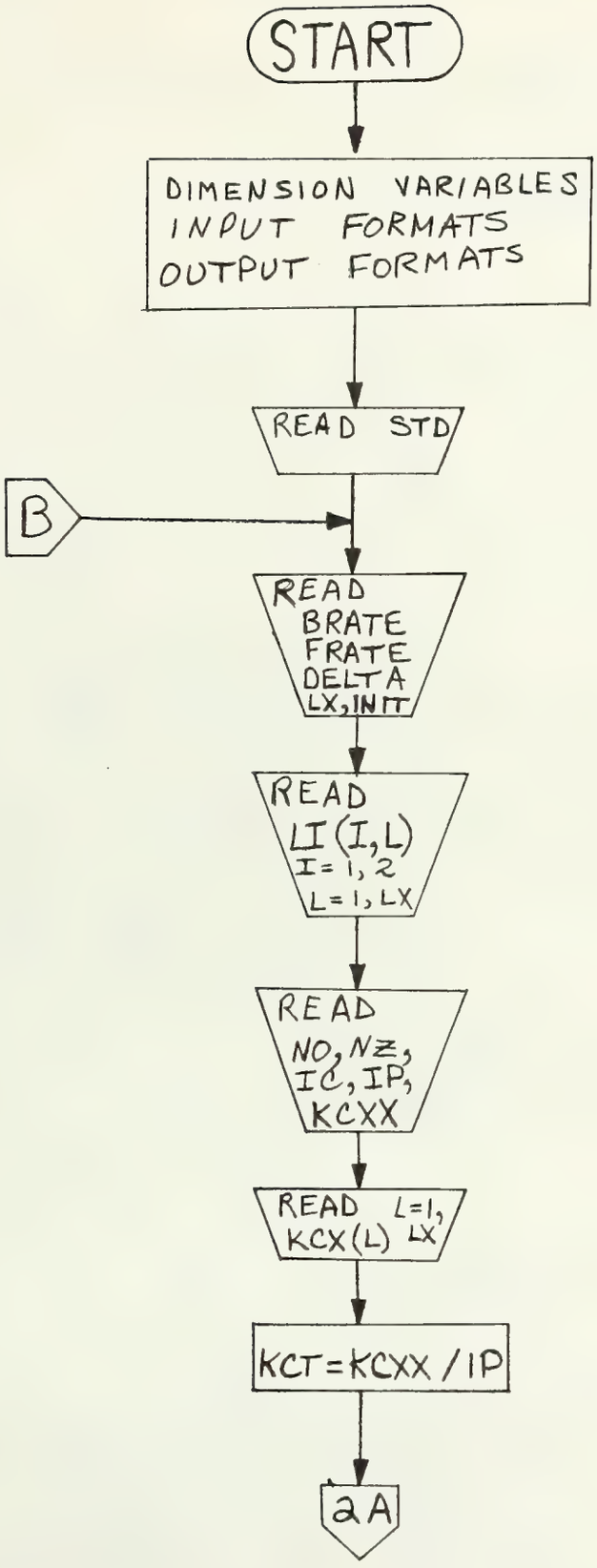
AN ENTRY FROM, OR EXIT
TO, ANOTHER PART OF
THE PROGRAM FLOWCHART

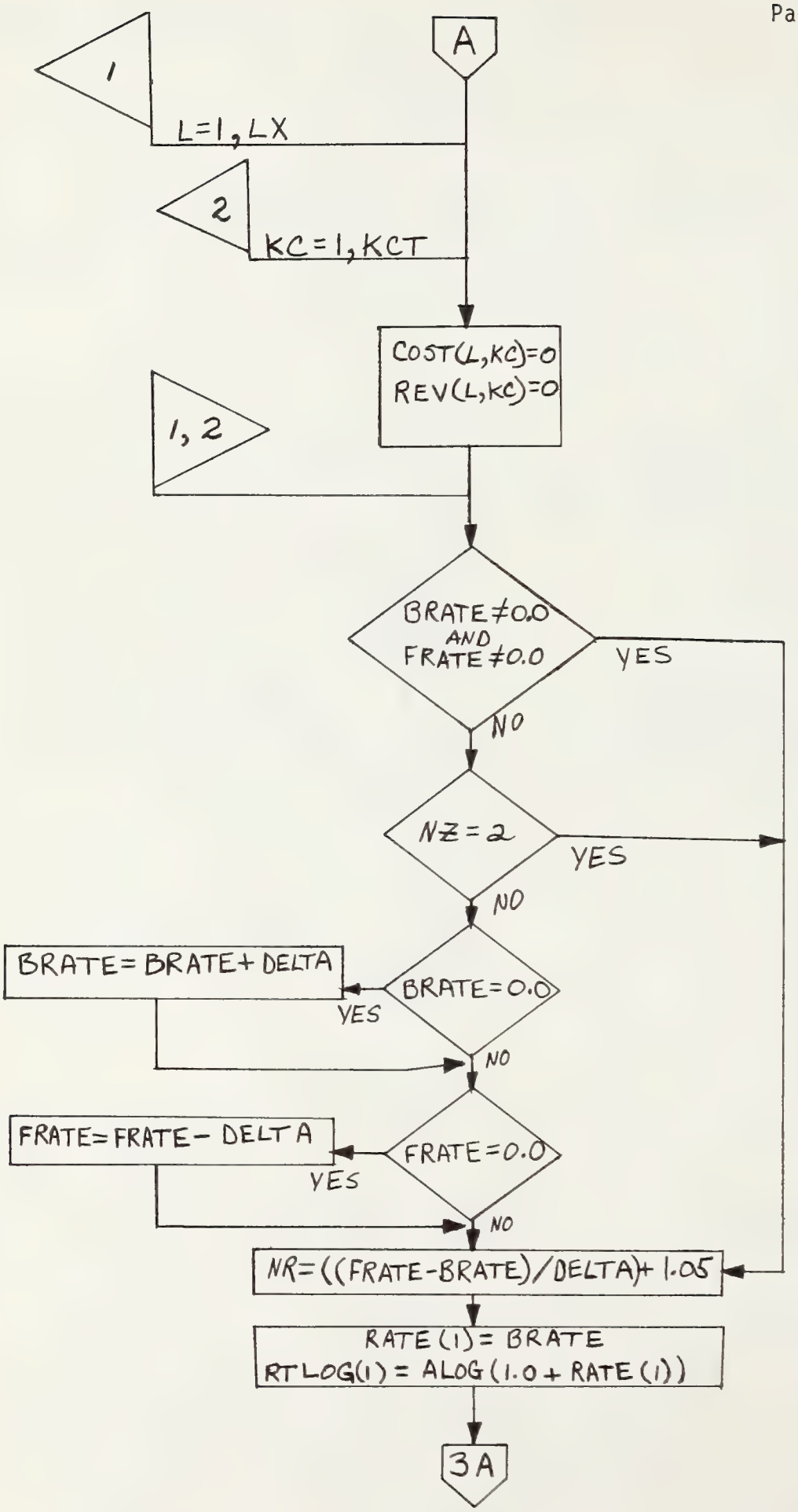
INPUT OR OUTPUT

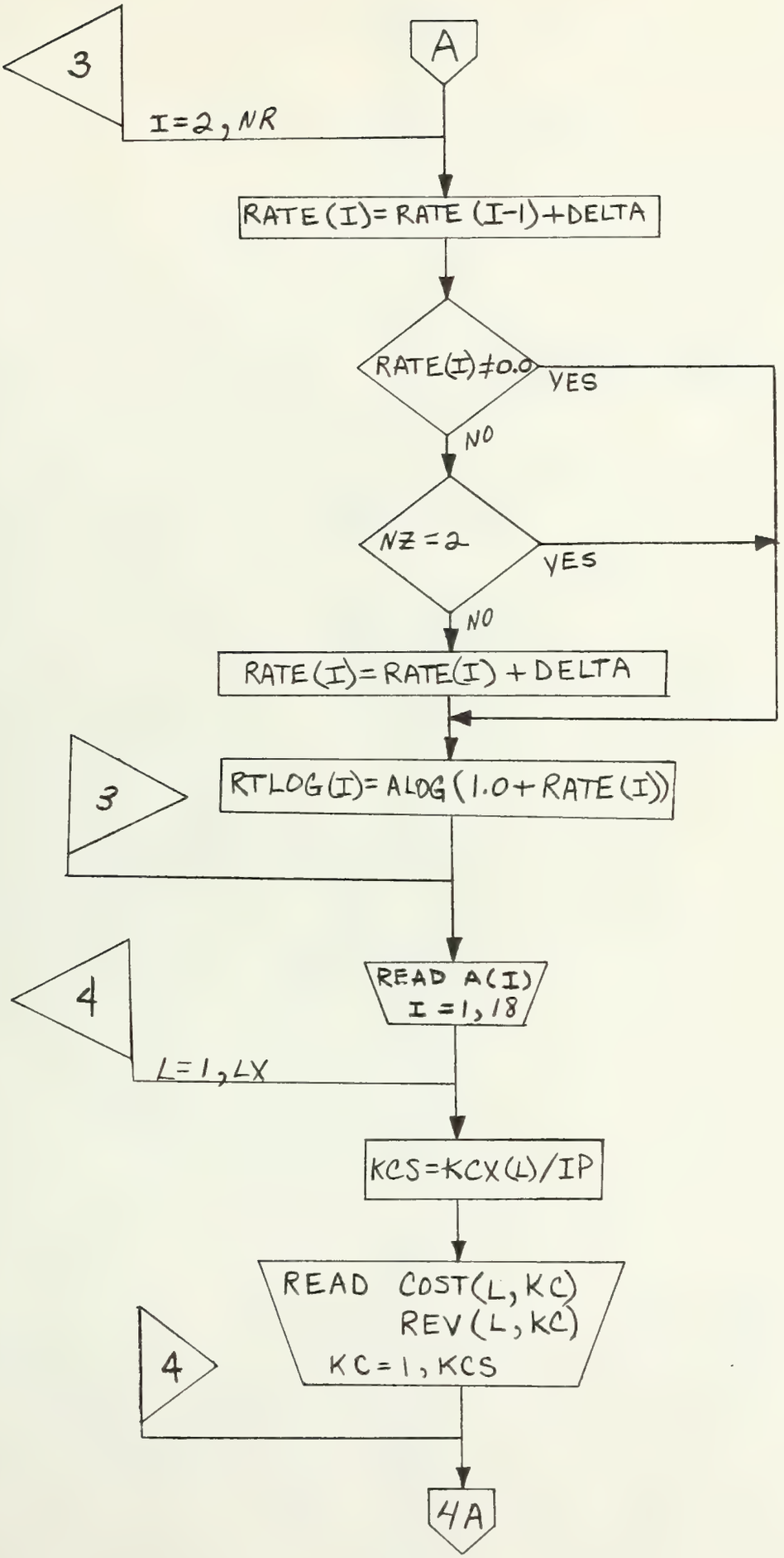
DIRECTION OF FLOW

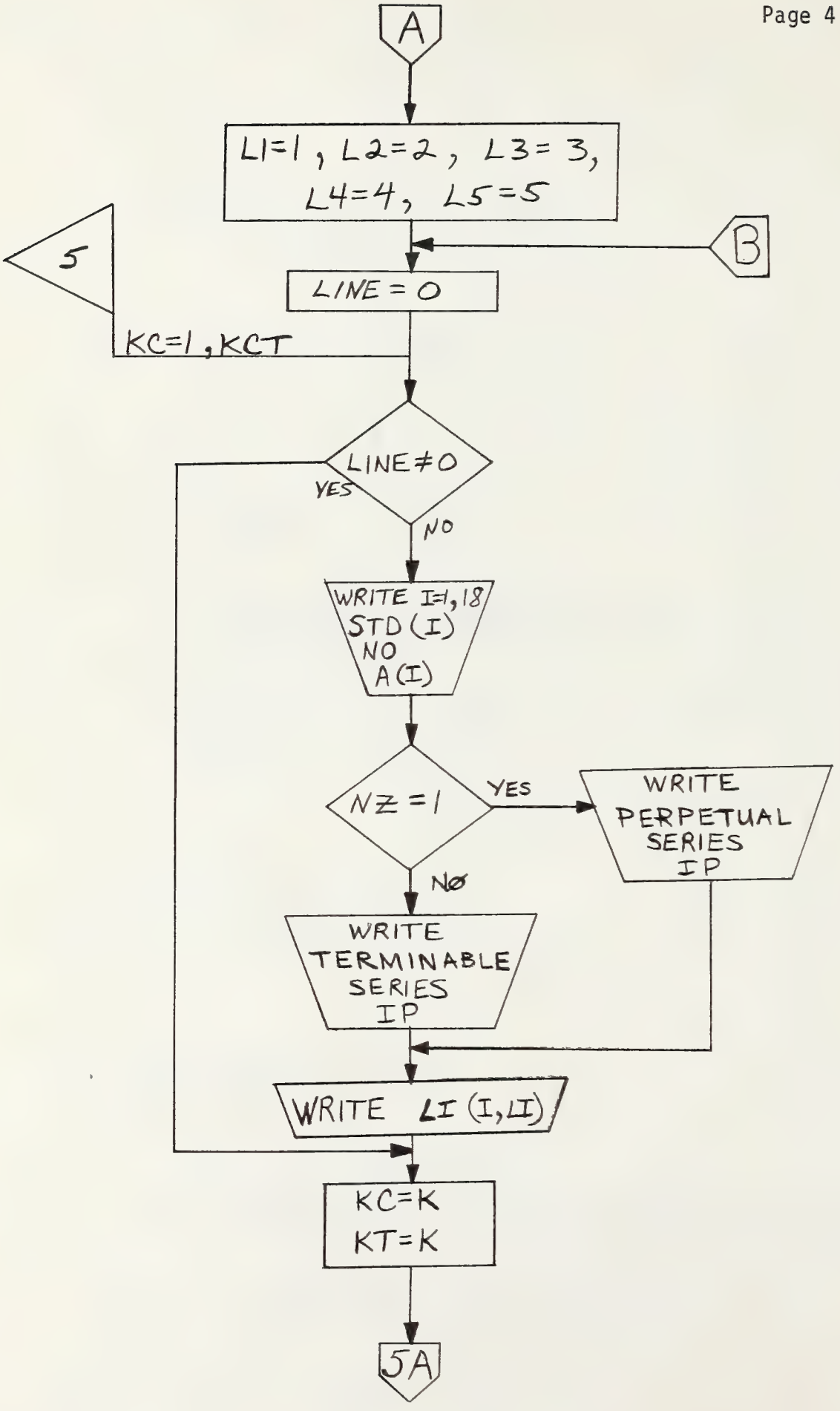


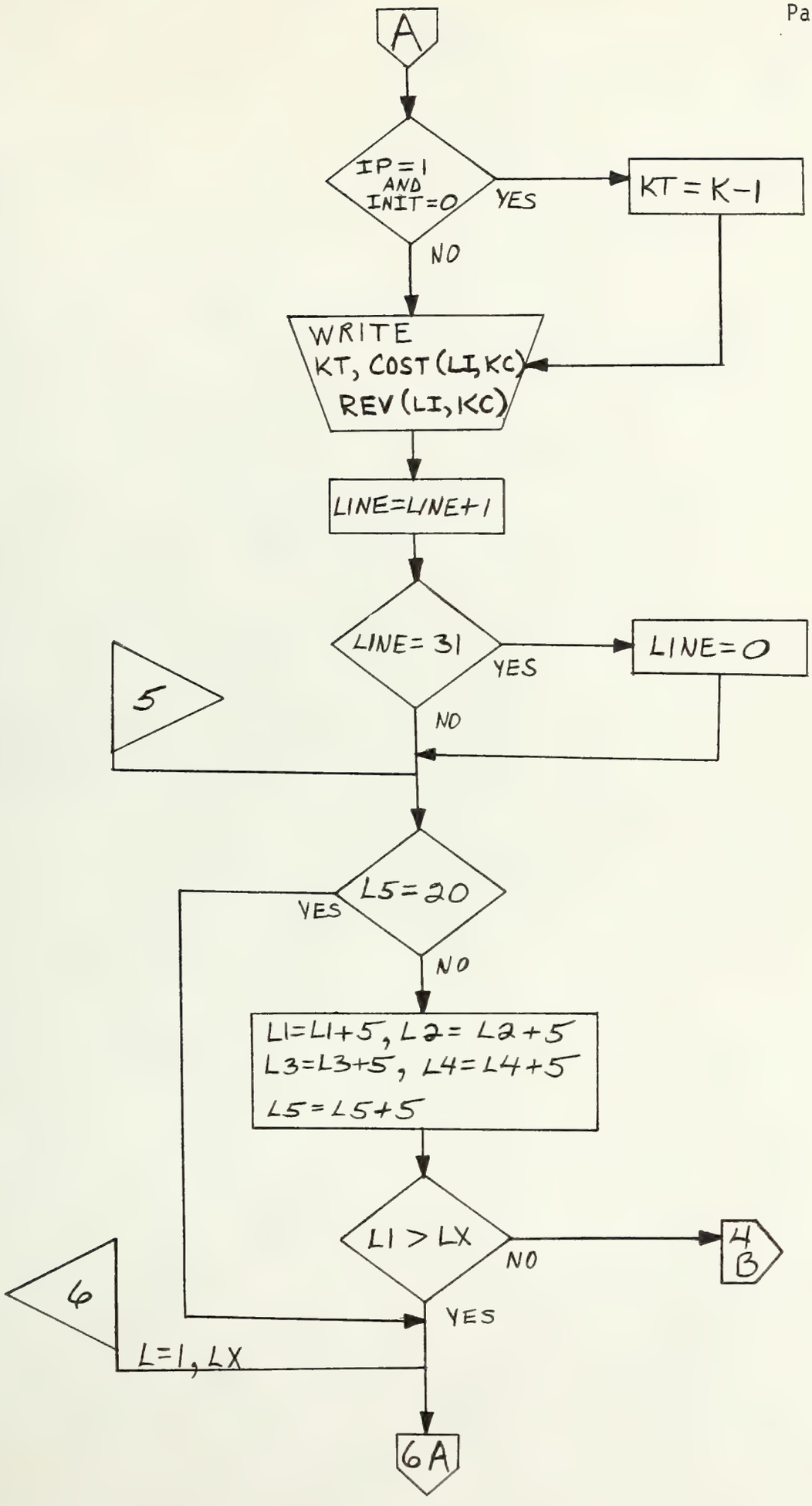
DECISION

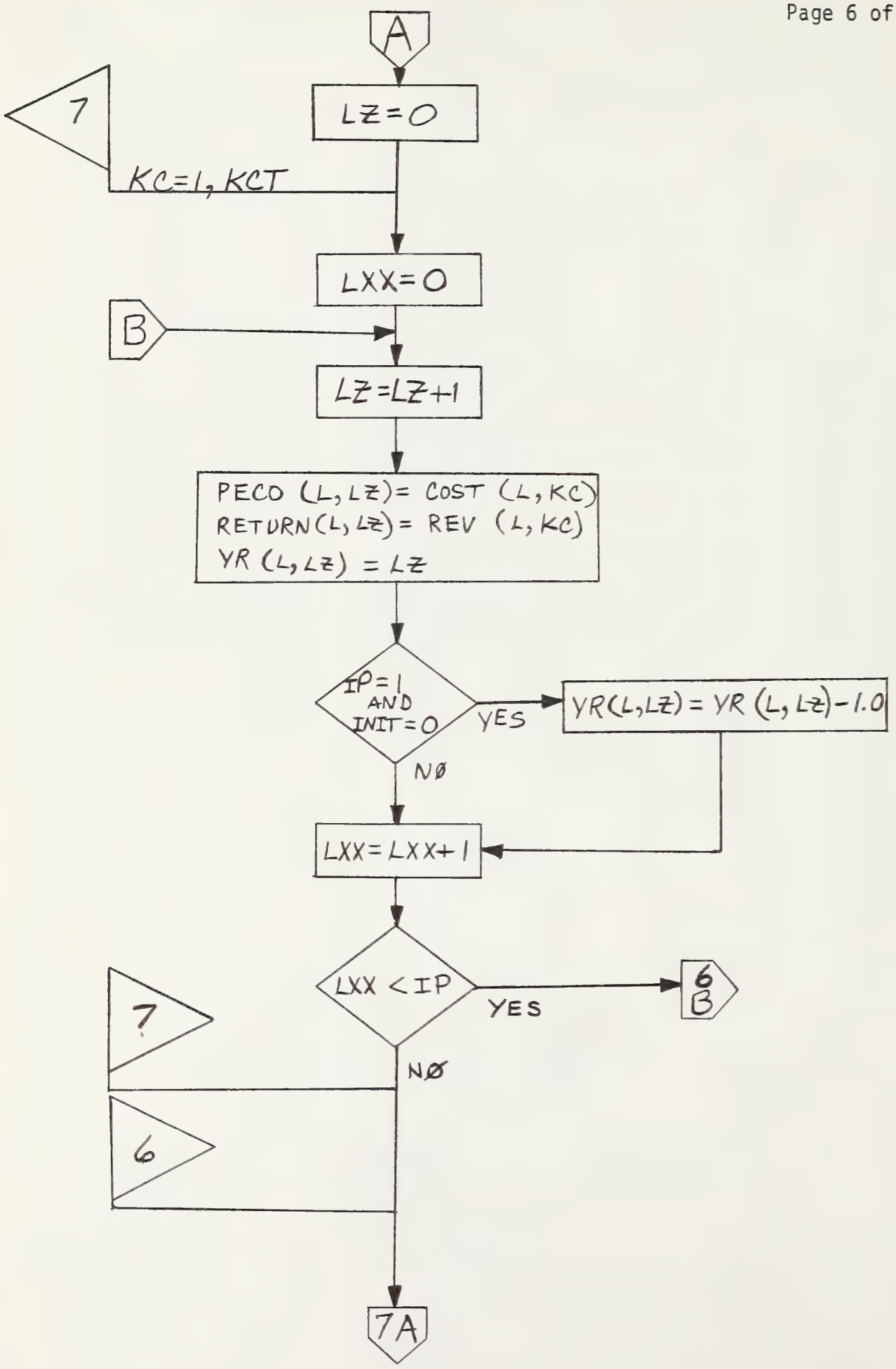

START
DIMENSION VARIABLES
INPUT FORMATS
OUTPUT FORMATS
READ STD
B
READ
BRATE
FRATE
DELTA
LX, INIT
READ
LI(I,L)
I=1,2
L=1,LX
READ
NO, NZ,
IC, IP,
KCXX
READ L=1,
KCX(L) LX
KCT=KCXX/IP
2A

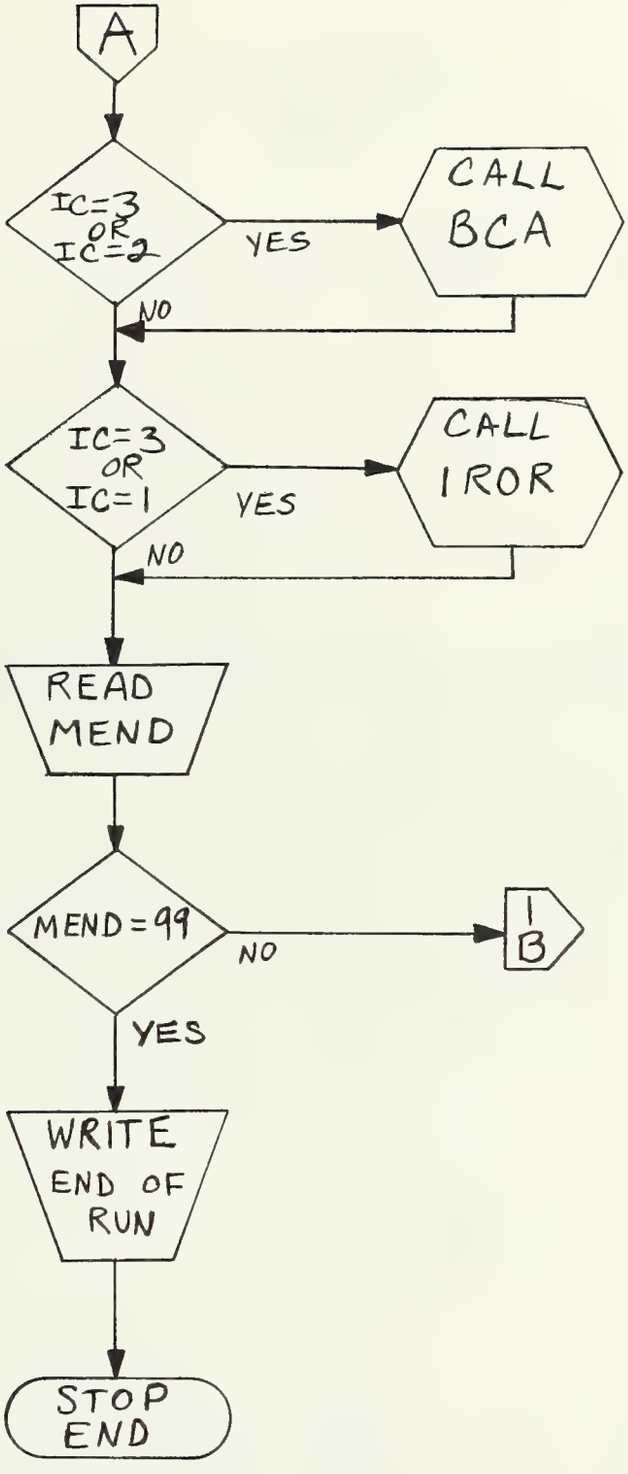

A
1
L=1, LX
2
KC=1, KCT
COST(L,KC)=0
REV(L,KC)=0
1, 2
BRATE≠0.0 AND FRATE≠0.0
YES
NO
NZ=2
YES
NO
BRATE=BRATE+DELTA
BRATE=0.0
YES
NO
FRATE=FRATE-DELTA
FRATE=0.0
YES
NO
NR=((FRATE-BRATE)/DELTA)+1.05
RATE(1)=BRATE
RTLOG(1)=ALOG(1.0+RATE(1))
3A


3
I=2, NR
A
RATE(I)= RATE (I-1)+DELTA
RATE(I)≠0.0
YES
NO
NZ = 2
YES
NO
RATE(I)= RATE(I) + DELTA
3
RTLOG(I)= ALOG (1.0+ RATE(I))
READ A(I)
I = 1, 18
4
L=1, LX
KCS=KCX(L)/IP
READ COST(L, KC)
REV(L, KC)
KC=1, KCS
4
4A

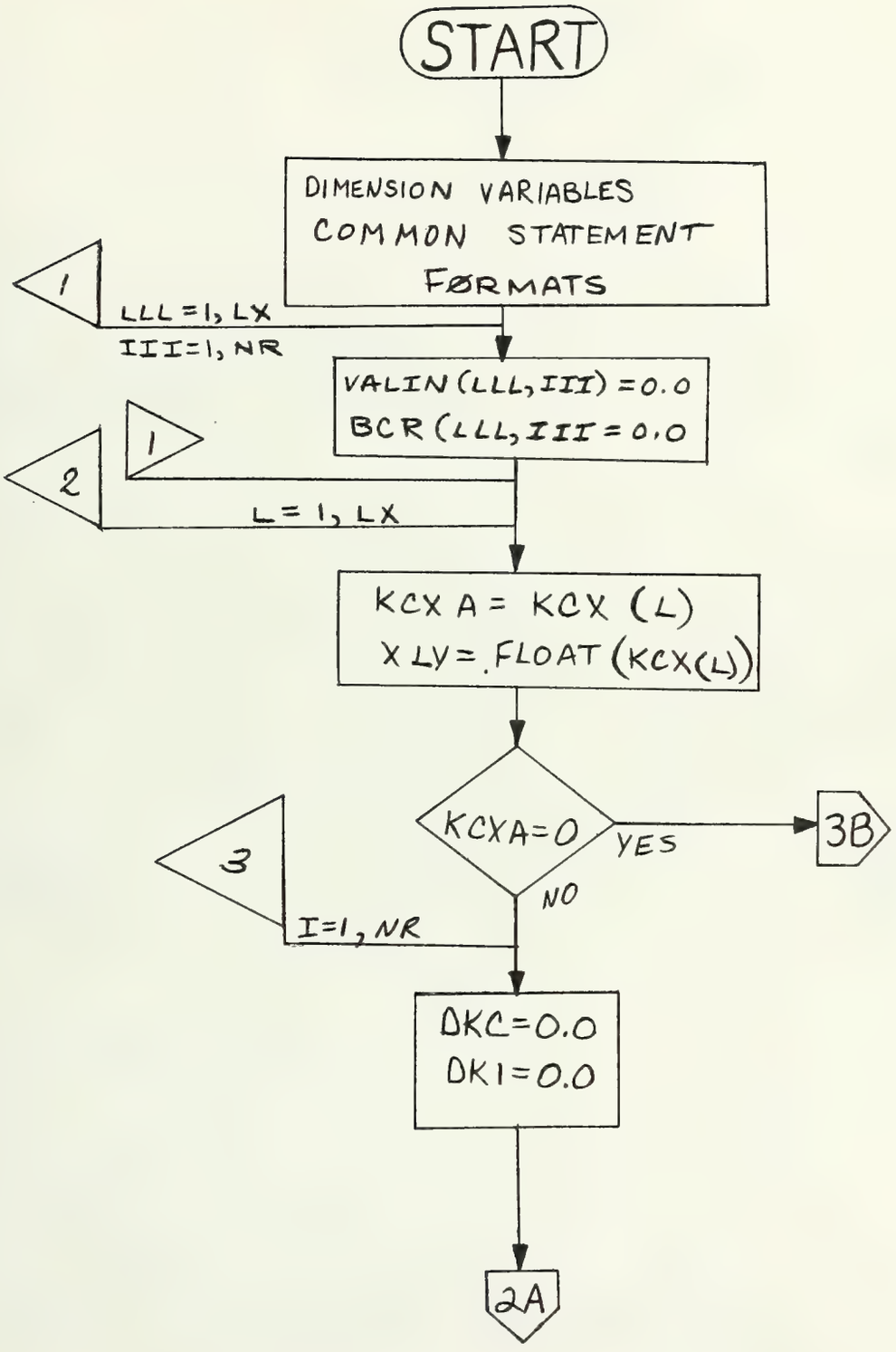

A
L1=1, L2=2, L3=3,
L4=4, L5=5
B
5
LINE=0
KC=1, KCT
LINE≠0
YES
NO
WRITE I=1,18
STD(I)
NO
A(I)
NZ=1
YES
WRITE
PERPETUAL
SERIES
IP
NØ
WRITE
TERMINABLE
SERIES
IP
WRITE LI(I,LI)
KC=K
KT=K
5A

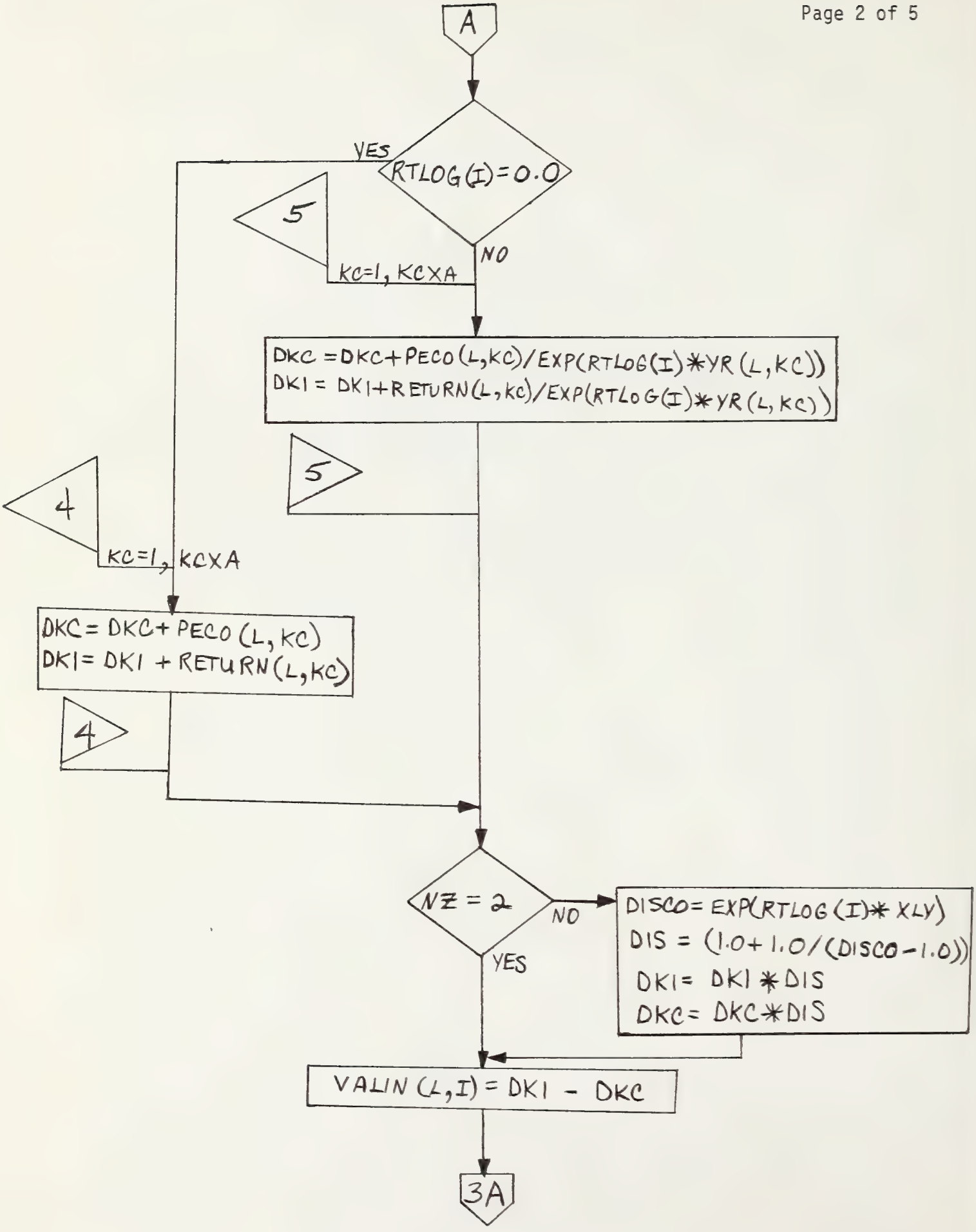

A
IP=1 AND INIT=0
YES
KT = K-1
NO
WRITE KT, COST(LI,KC) REV(LI,KC)
LINE=LINE+1
LINE=31
YES
LINE=0
NO
5
L5=20
YES
NO
LI=LI+5, L2=L2+5
L3=L3+5, L4=L4+5
L5=L5+5
LI > LX
NO
4 B
YES
6
L=1, LX
6A

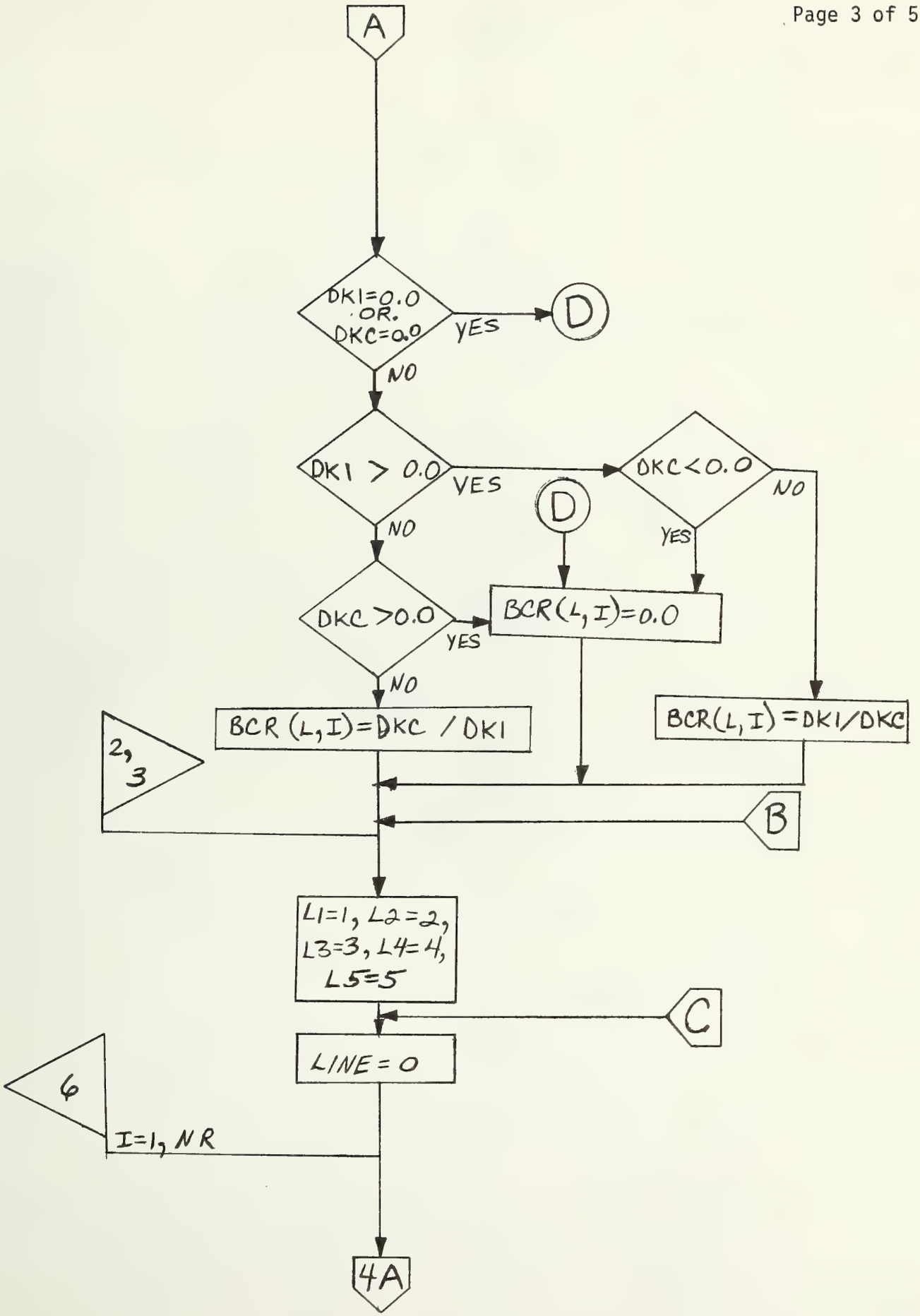

A
LZ=0
7
KC=1, KCT
LXX=0
B
LZ=LZ+1
PECO (L, LZ)= COST (L, KC)
RETURN(L, LZ)= REV (L, KC)
YR (L, LZ) = LZ
IP=1 AND INIT=0
YES
YR(L,LZ) = YR (L, LZ)-1.0
NØ
LXX=LXX+1
LXX < IP
YES
6 B
7
NØ
6
7A

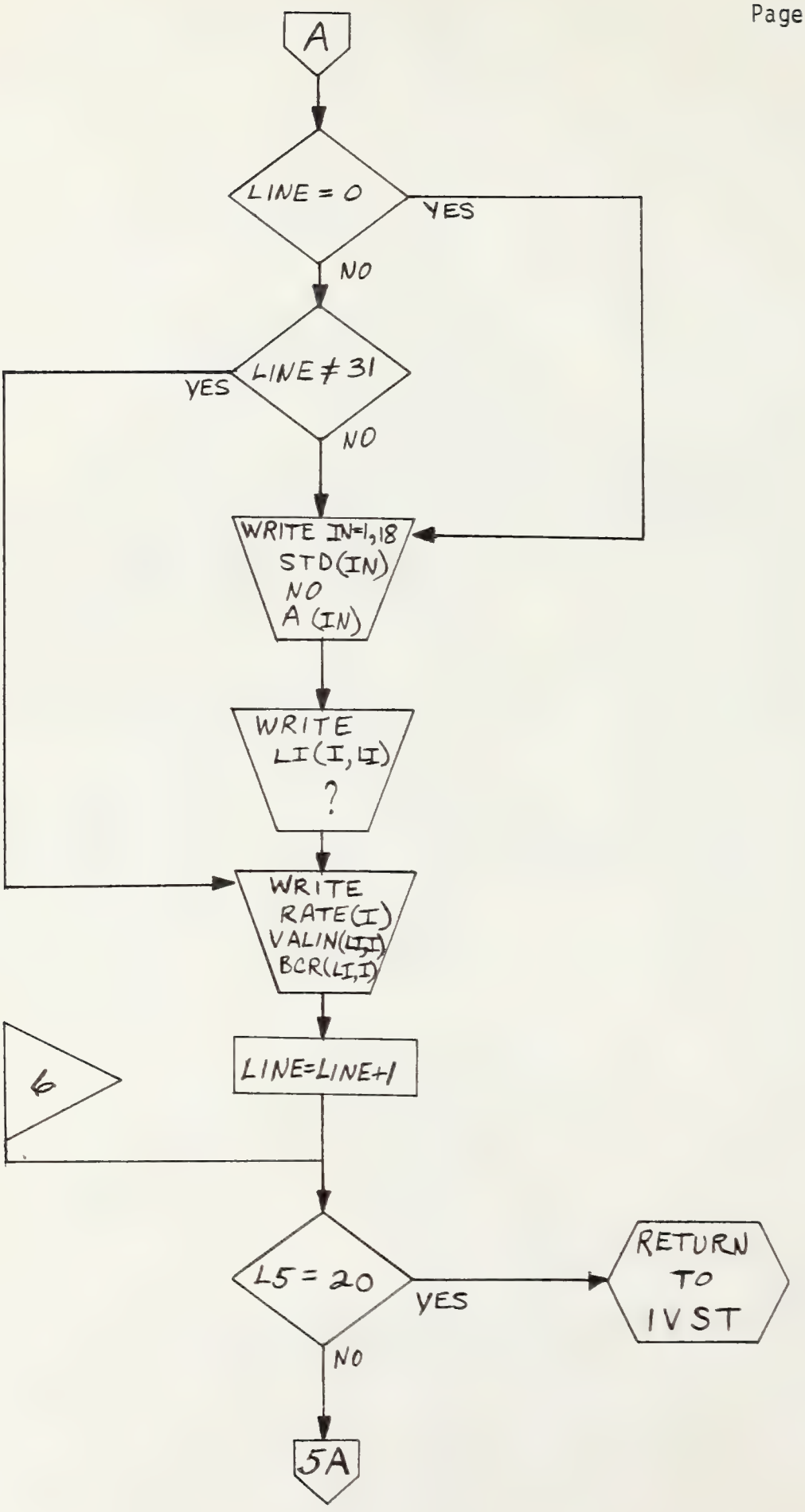

A
IC=3 OR IC=2
YES
CALL BCA
NO
IC=3 OR IC=1
YES
CALL IROR
NO
READ MEND
MEND=99
NO
1 B
YES
WRITE END OF RUN
STOP END

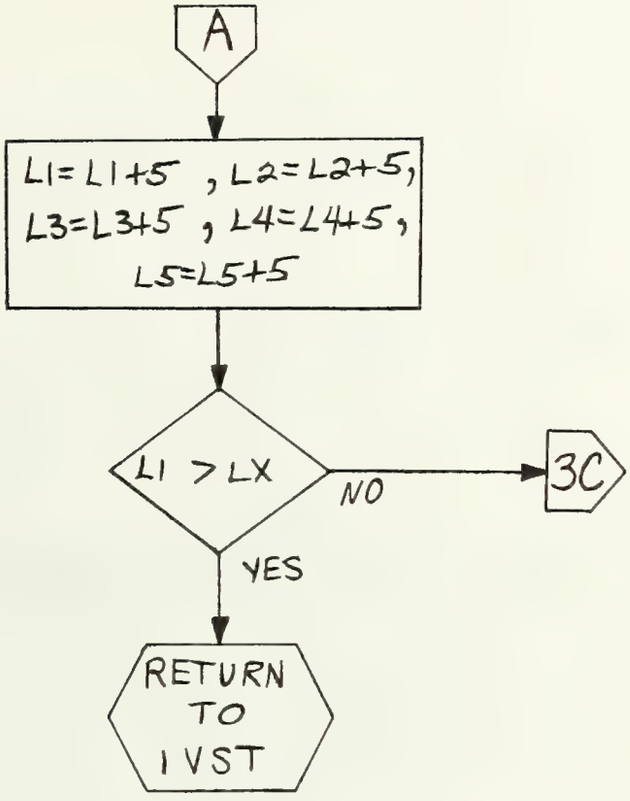
FLOW CHART FOR SUBROUTINE BCA


START
DIMENSION VARIABLES
COMMON STATEMENT
FORMATS
1
LLL=1, LX
III=1, NR
VALIN(LLL, III)=0.0
BCR(LLL, III=0.0
1
2
L=1, LX
KCX A = KCX (L)
X LY = FLOAT (KCX(L))
KCXA=0
YES
3B
NO
3
I=1, NR
DKC=0.0
DK1=0.0
2A

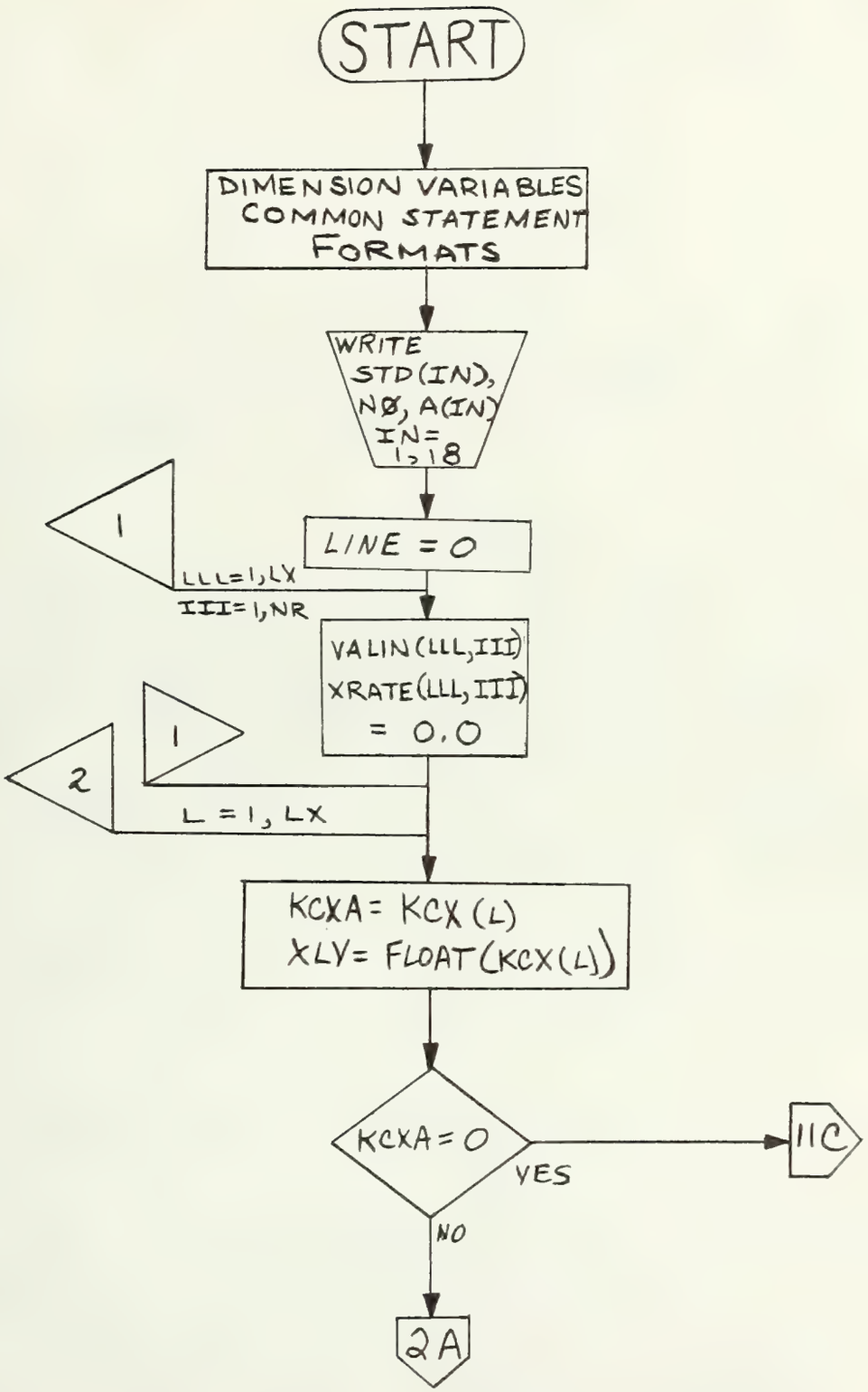

A
YES
RTLOG(I)=0.0
NO
5
KC=1, KCXA
DKC =DKC+PECO(L,KC)/EXP(RTLOG(I)*YR(L,KC))
DKI = DKI+RETURN(L,KC)/EXP(RTLOG(I)*YR(L,KC))
5
4
KC=1, KCXA
DKC= DKC+ PECO (L, KC)
DKI= DKI + RETURN(L,KC)
4
NZ = 2
NO
YES
DISCO= EXP(RTLOG (I)* XLY)
DIS = (1.0+ 1.0/(DISCO-1.0))
DKI= DKI *DIS
DKC= DKC*DIS
VALIN (L,I) = DKI - DKC
3A

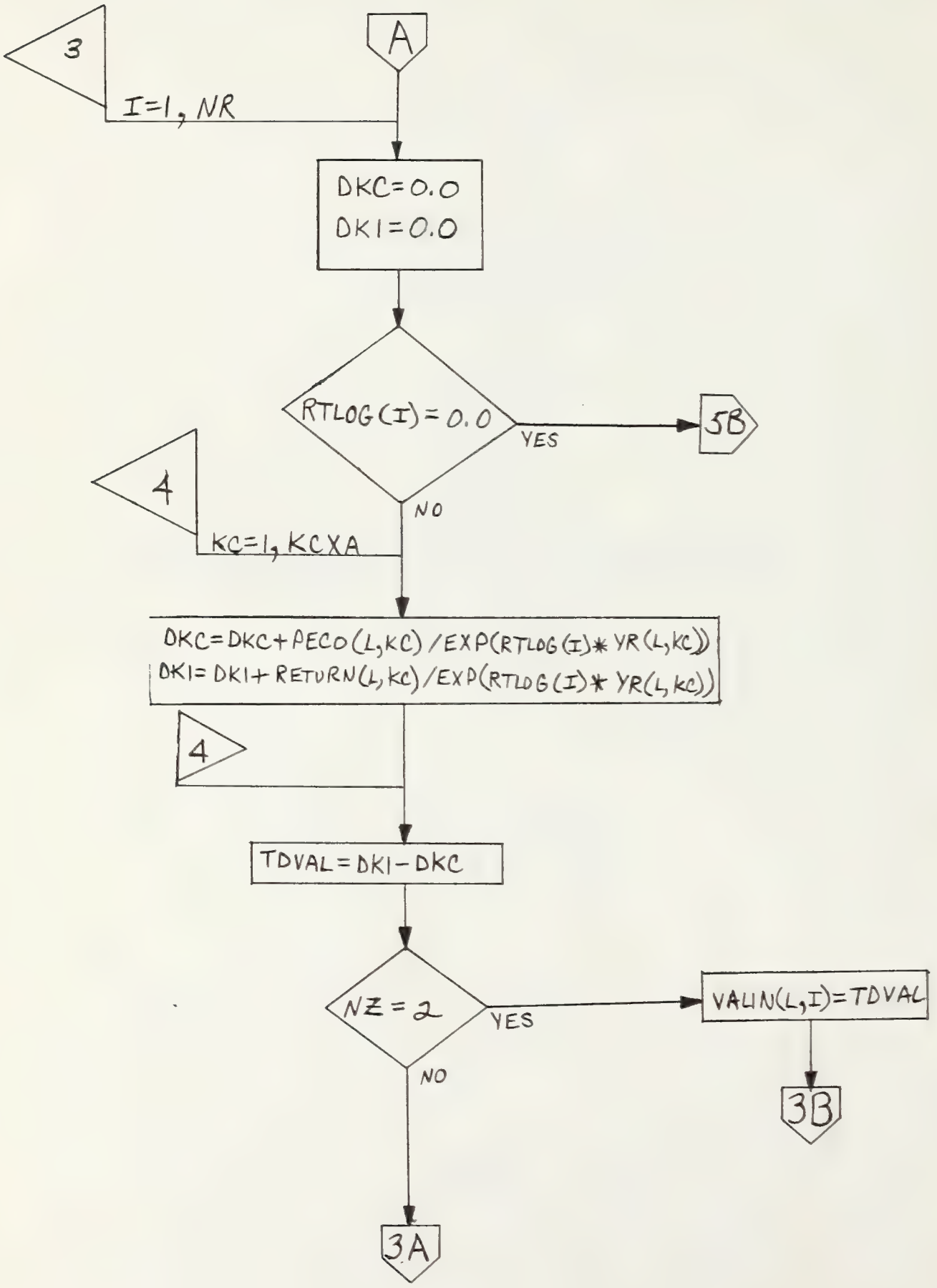

A
DK1=0.0 .OR. DKC=0.0
YES
D
NO
DK1 > 0.0
YES
DKC<0.0
NO
D
NO
YES
DKC >0.0
YES
BCR(L,I)=0.0
NO
BCR (L,I)=DKC / DK1
BCR(L,I) =DK1/DKC
2, 3
B
L1=1, L2=2, L3=3, L4=4, L5=5
C
LINE = 0
6
I=1, NR
4A

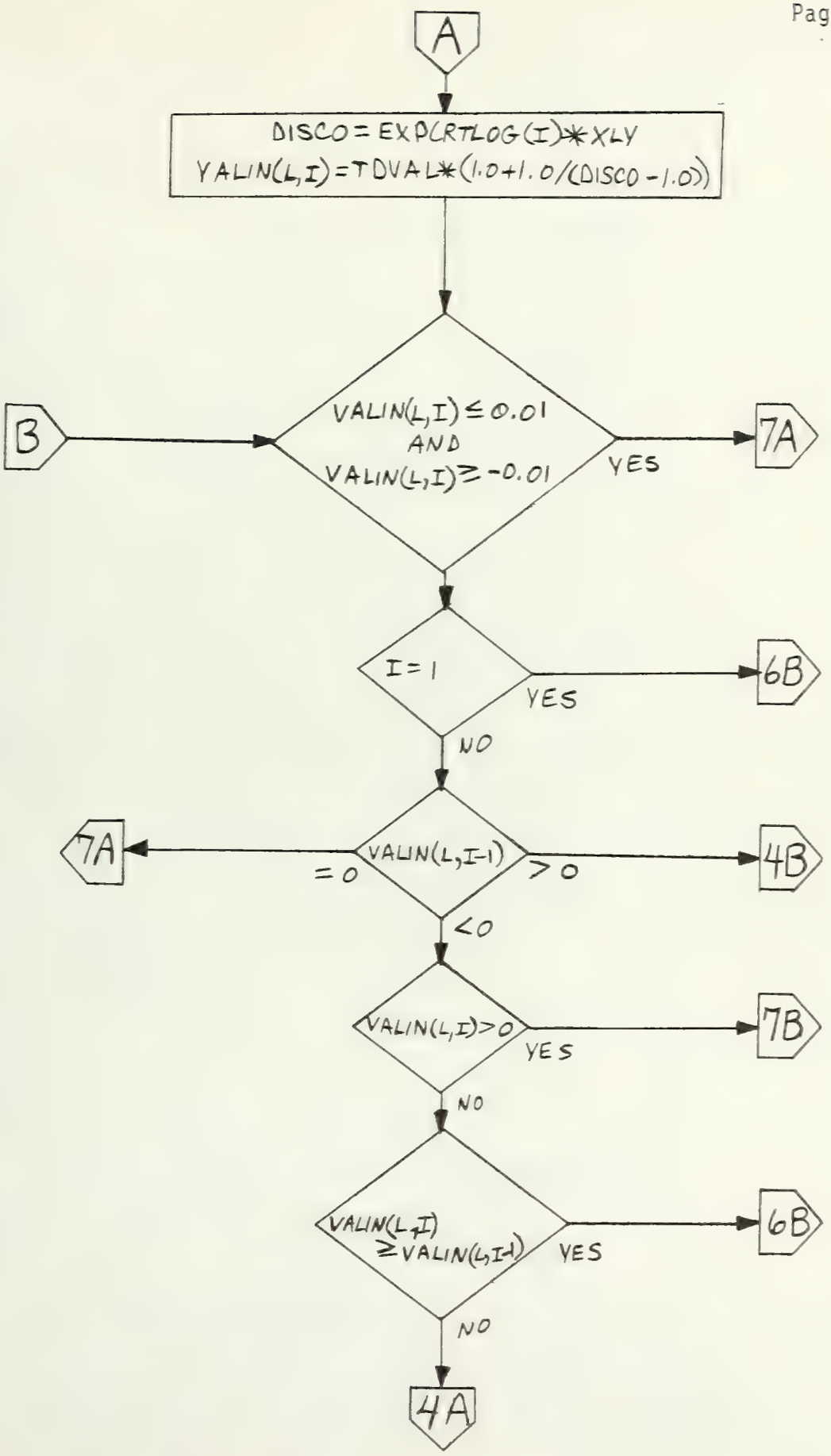

A
LINE = 0
YES
NO
LINE ≠ 31
YES
NO
WRITE IN=1,18
STD(IN)
NO
A (IN)
WRITE
LI(I,LI)
?
WRITE
RATE(I)
VALIN(LI,I)
BCR(LI,I)
6
LINE=LINE+1
L5 = 20
YES
RETURN
TO
IVST
NO
5A

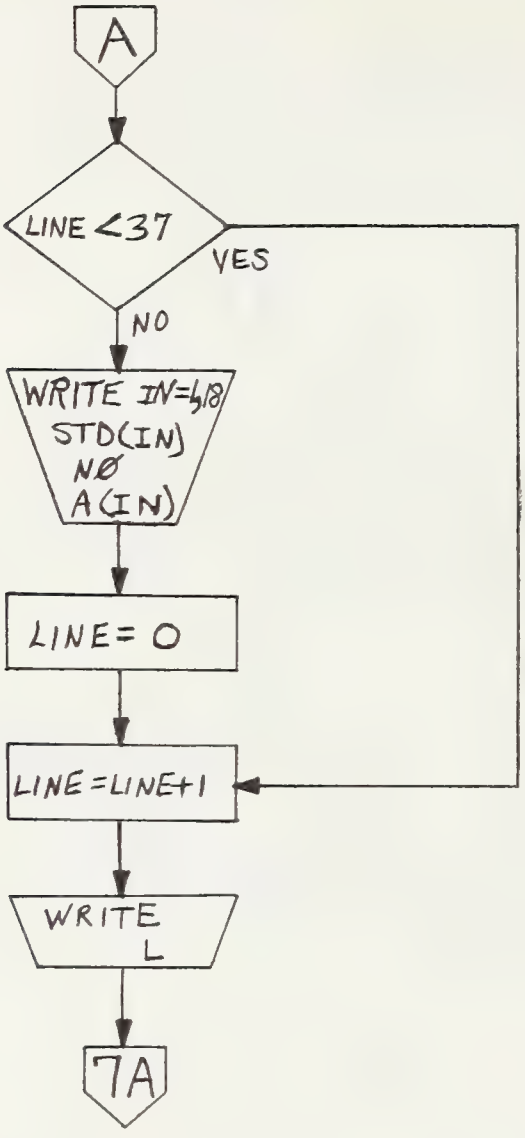

A
L1=L1+5 , L2=L2+5,
L3=L3+5 , L4=L4+5,
L5=L5+5
L1 > LX
NO
3C
YES
RETURN
TO
IVST

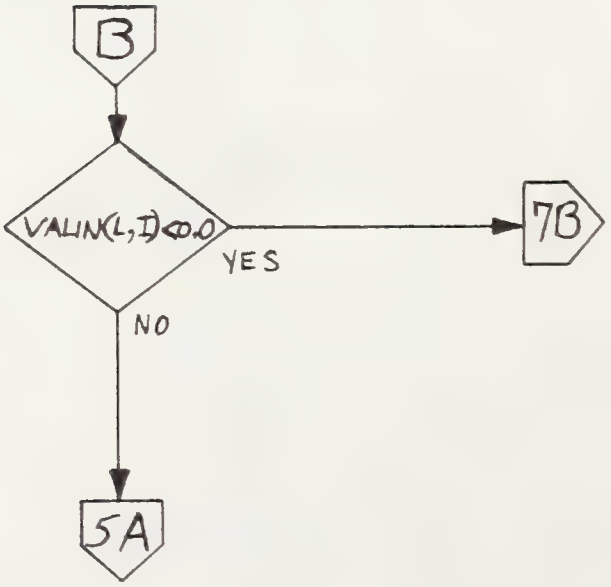
FLOW CHART FOR SUBROUTINE IROR

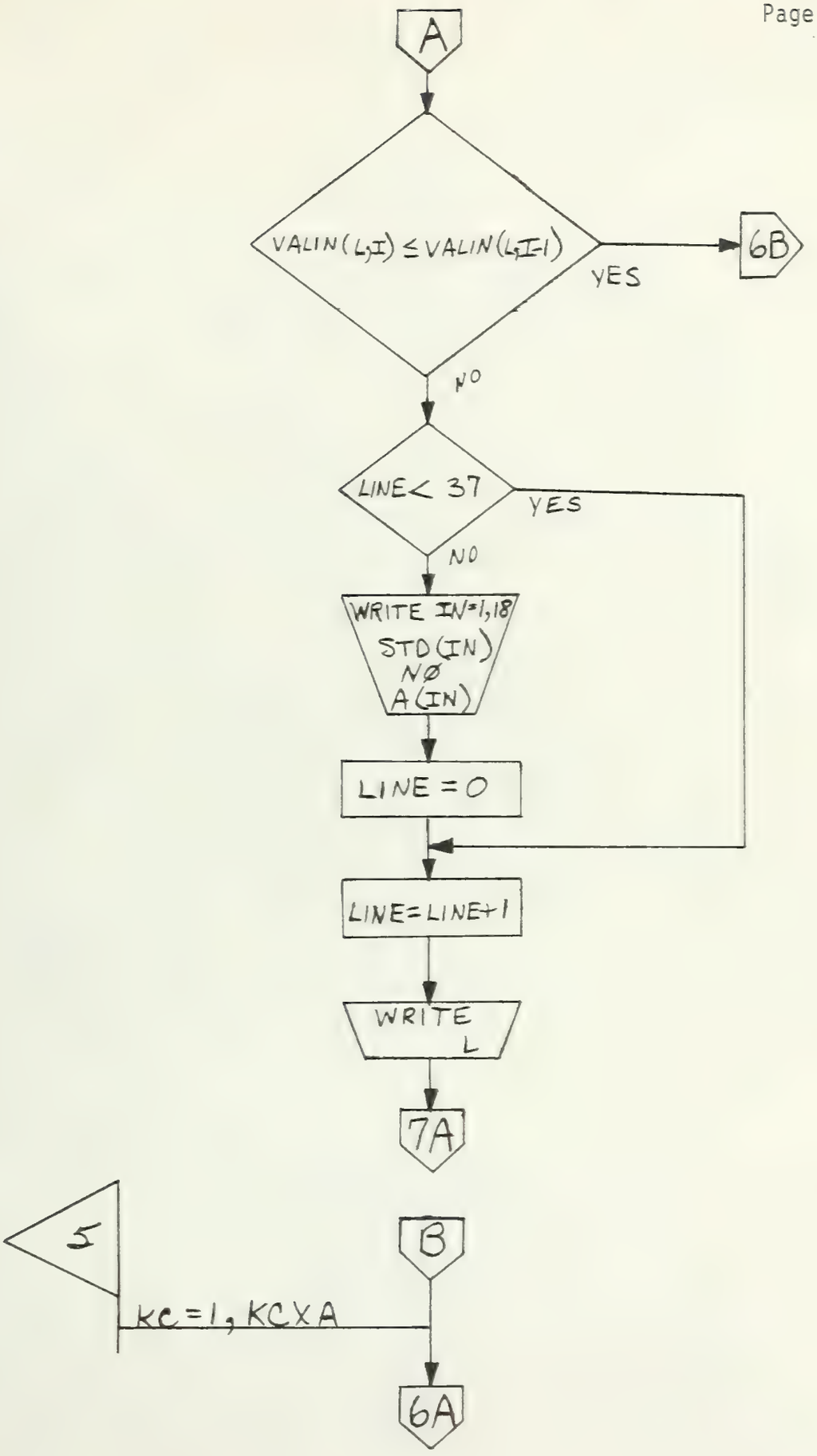

START
DIMENSION VARIABLES
COMMON STATEMENT
FORMATS
WRITE
STD(IN),
NØ, A(IN)
IN=
1,18
1
LLL=1,LX
III=1,NR
LINE = 0
VALIN(LLL,III)
XRATE(LLL,III)
= 0.0
1
2
L = 1, LX
KCXA = KCX(L)
XLV = FLOAT(KCX(L))
KCXA = 0
YES
NO
11C
2A

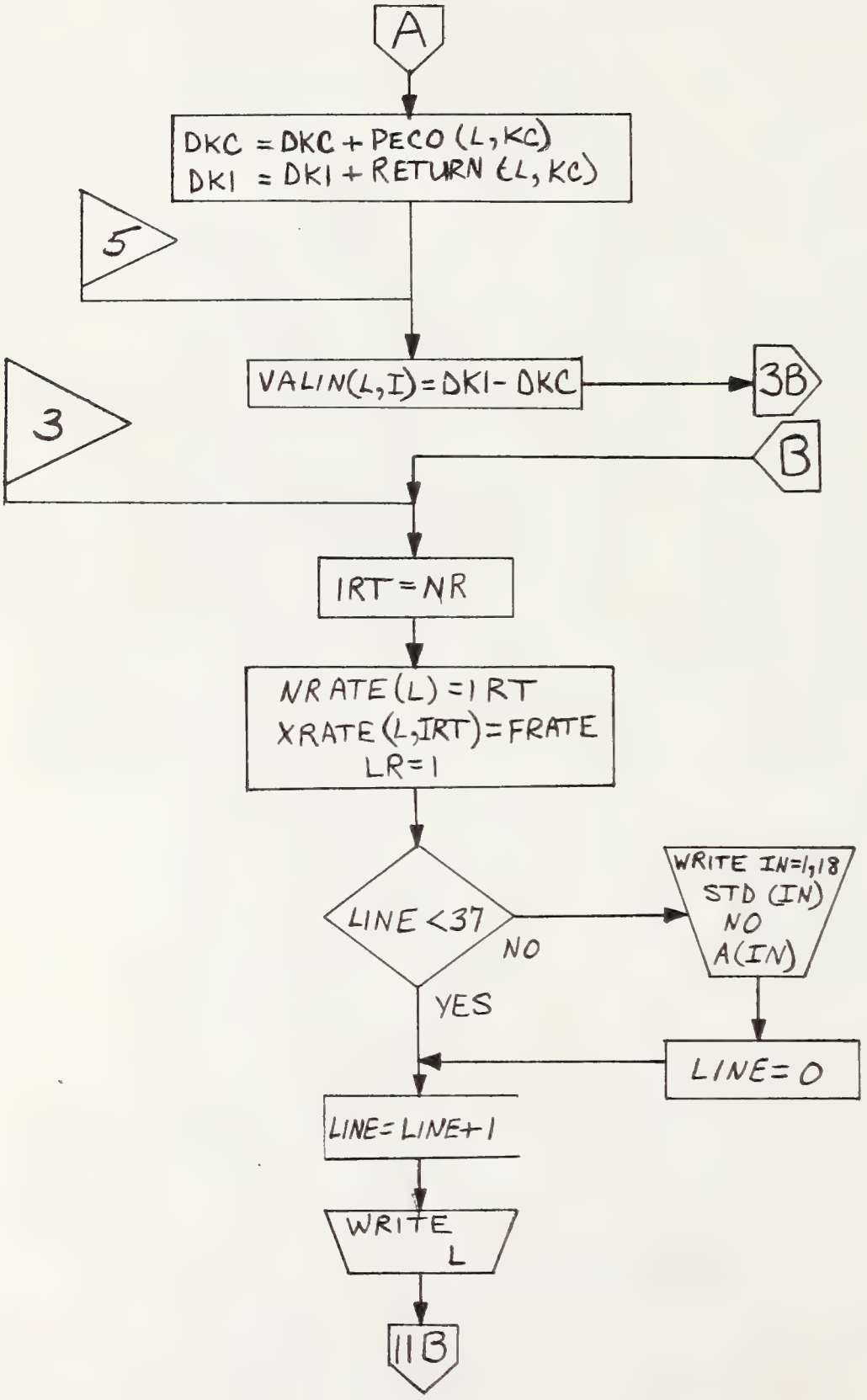

3
I=1, NR
A
DKC=0.0
DKI=0.0
RTLOG(I)=0.0
YES
5B
NO
4
KC=1, KCXA
DKC=DKC+PECO(L,KC)/EXP(RTLOG(I)*YR(L,KC))
DKI=DKI+RETURN(L,KC)/EXP(RTLOG(I)*YR(L,KC))
4
TDVAL=DKI-DKC
NZ=2
YES
VALIN(L,I)=TDVAL
3B
NO
3A

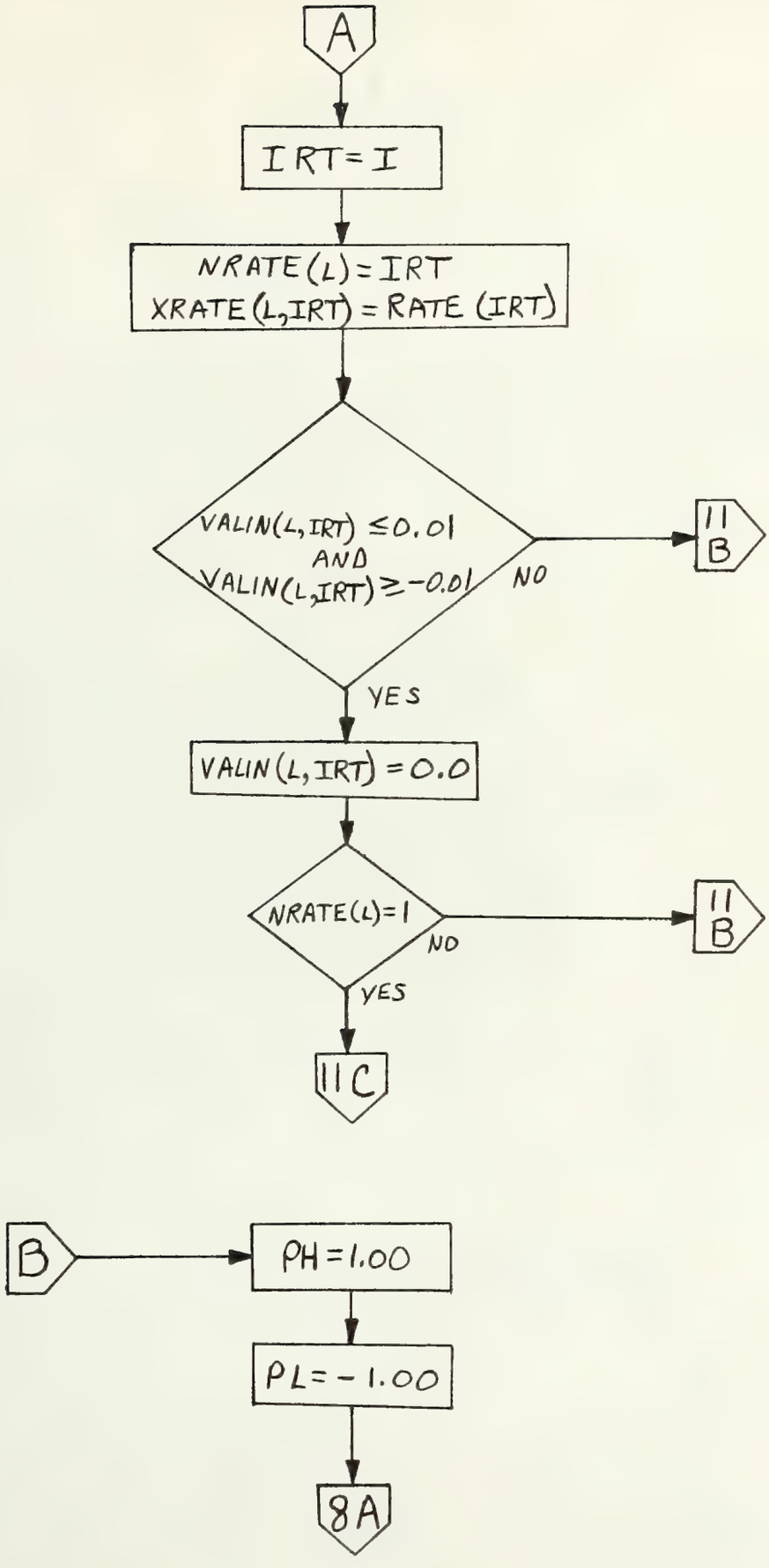

A
DISCO = EXP(RTLOG(I)*XLV
YALIN(L,I) = TDVAL*(1.0+1.0/(DISCO-1.0))
B
VALIN(L,I) ≤ 0.01
AND
VALIN(L,I) ≥ -0.01
YES
7A
I = 1
YES
6B
NO
7A
VALIN(L,I-1)
= 0
> 0
4B
< 0
VALIN(L,I) > 0
YES
7B
NO
VALIN(L,I)
≥ VALIN(L,I-1)
YES
6B
NO
4A

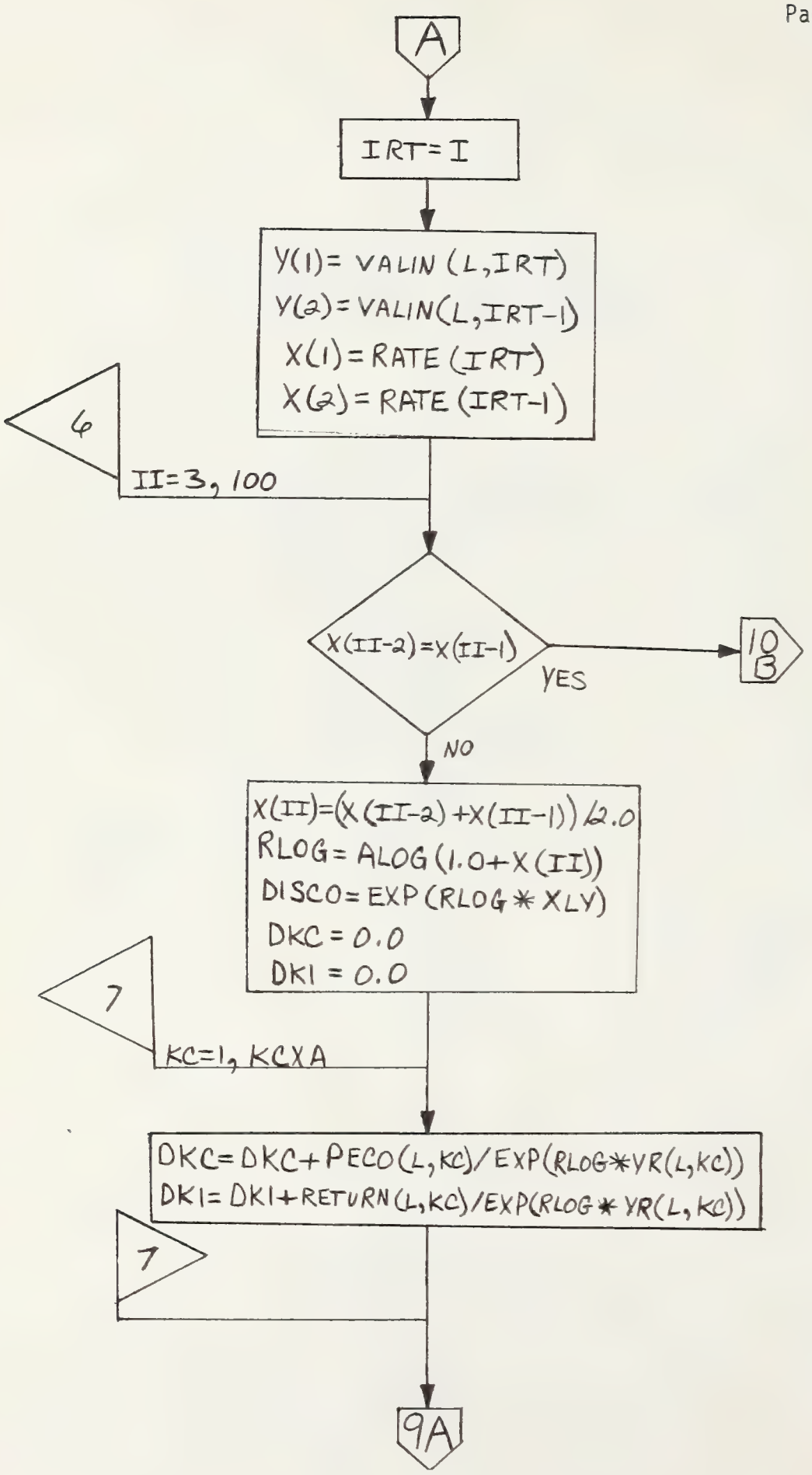

A
LINE <37
YES
NO
WRITE IN=4,18
STD(IN)
NØ
A(IN)
LINE= 0
LINE =LINE+1
WRITE
L
7A

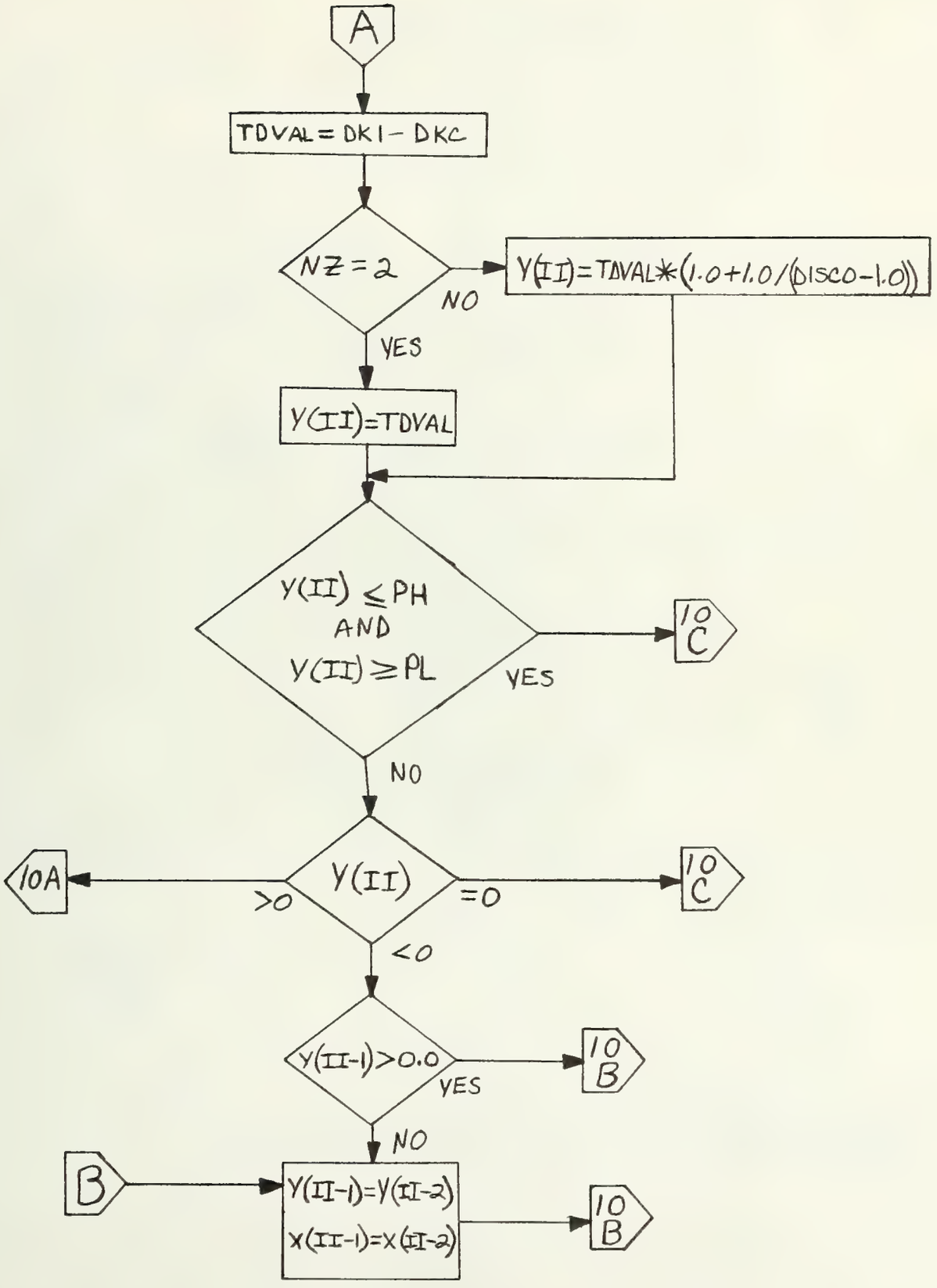

B
VALIN(L,I)<0.0
YES
7B
NO
5A

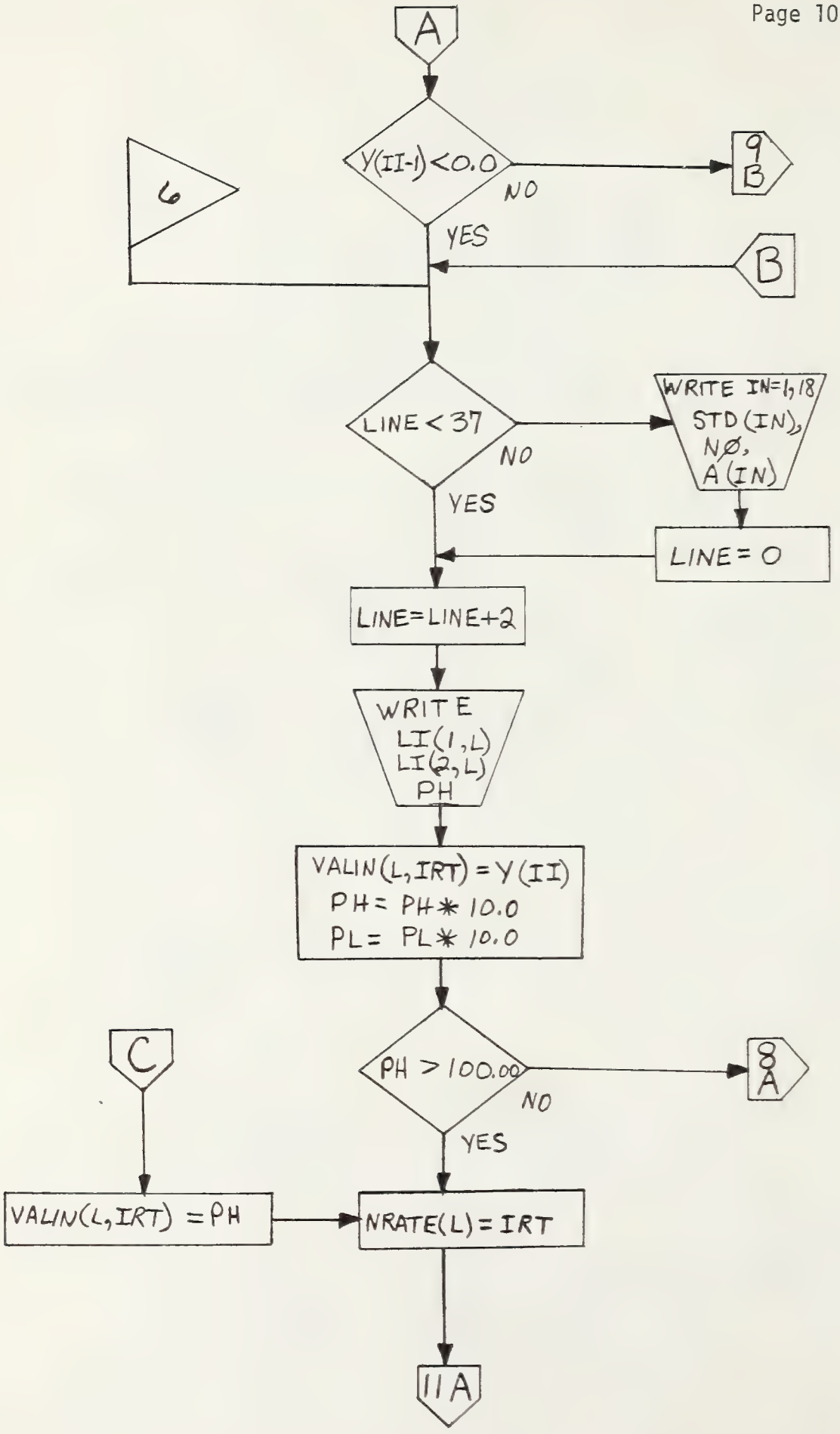

A
VALIN(L,I) ≤ VALIN(L,I-1)
YES
6B
NO
LINE< 37
YES
NO
WRITE IN=1,18
STD(IN)
NØ
A(IN)
LINE=0
LINE=LINE+1
WRITE
L
7A
5
B
KC=1, KCXA
6A

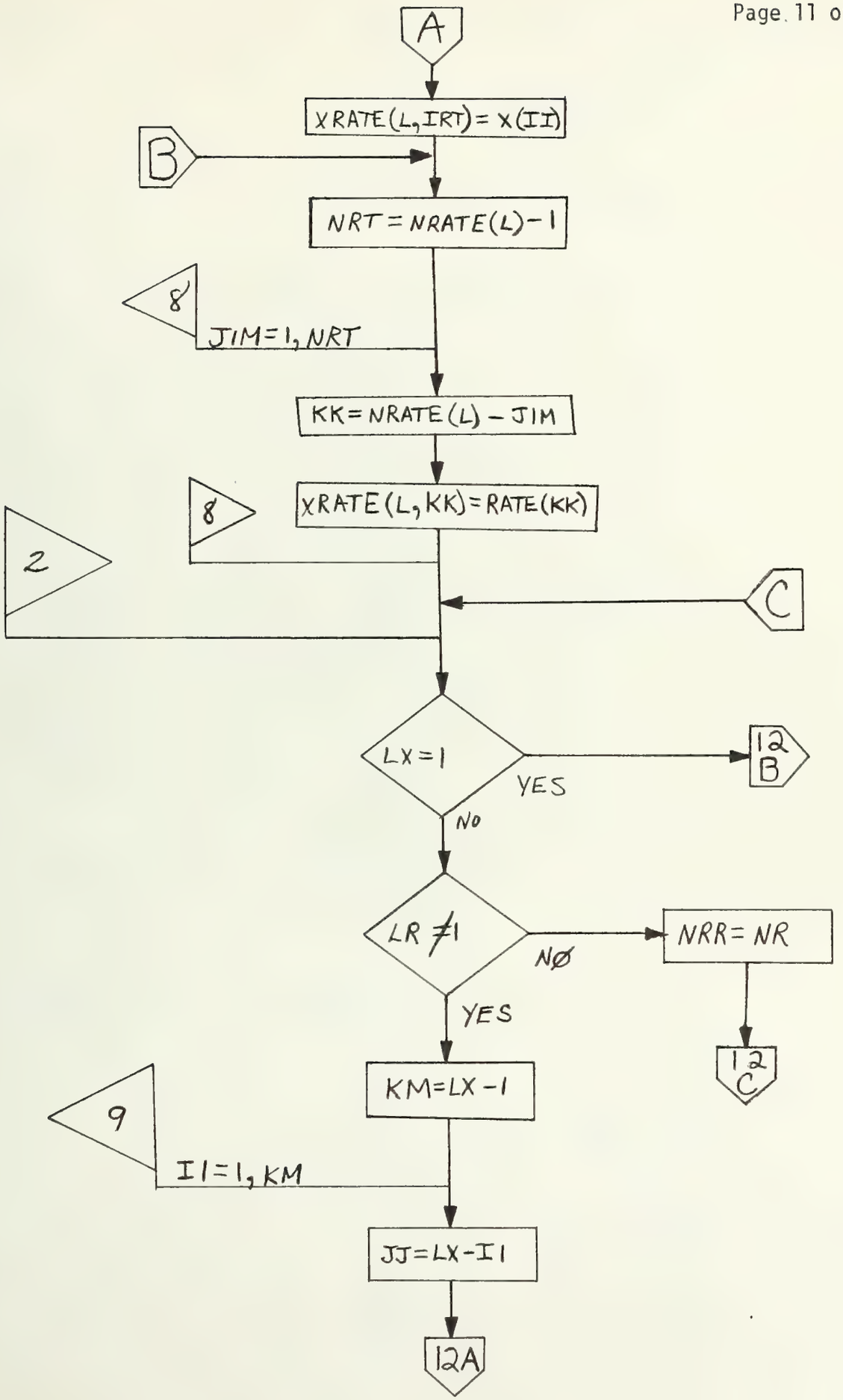

A
DKC = DKC + PECO (L, KC)
DKI = DKI + RETURN (L, KC)
5
VALIN(L,I) = DKI - DKC
3B
3
B
IRT = NR
NRATE(L) = IRT
XRATE(L,IRT) = FRATE
LR = 1
LINE < 37
NO
WRITE IN=1,18
STD (IN)
NO
A(IN)
YES
LINE = 0
LINE = LINE + 1
WRITE
L
11B

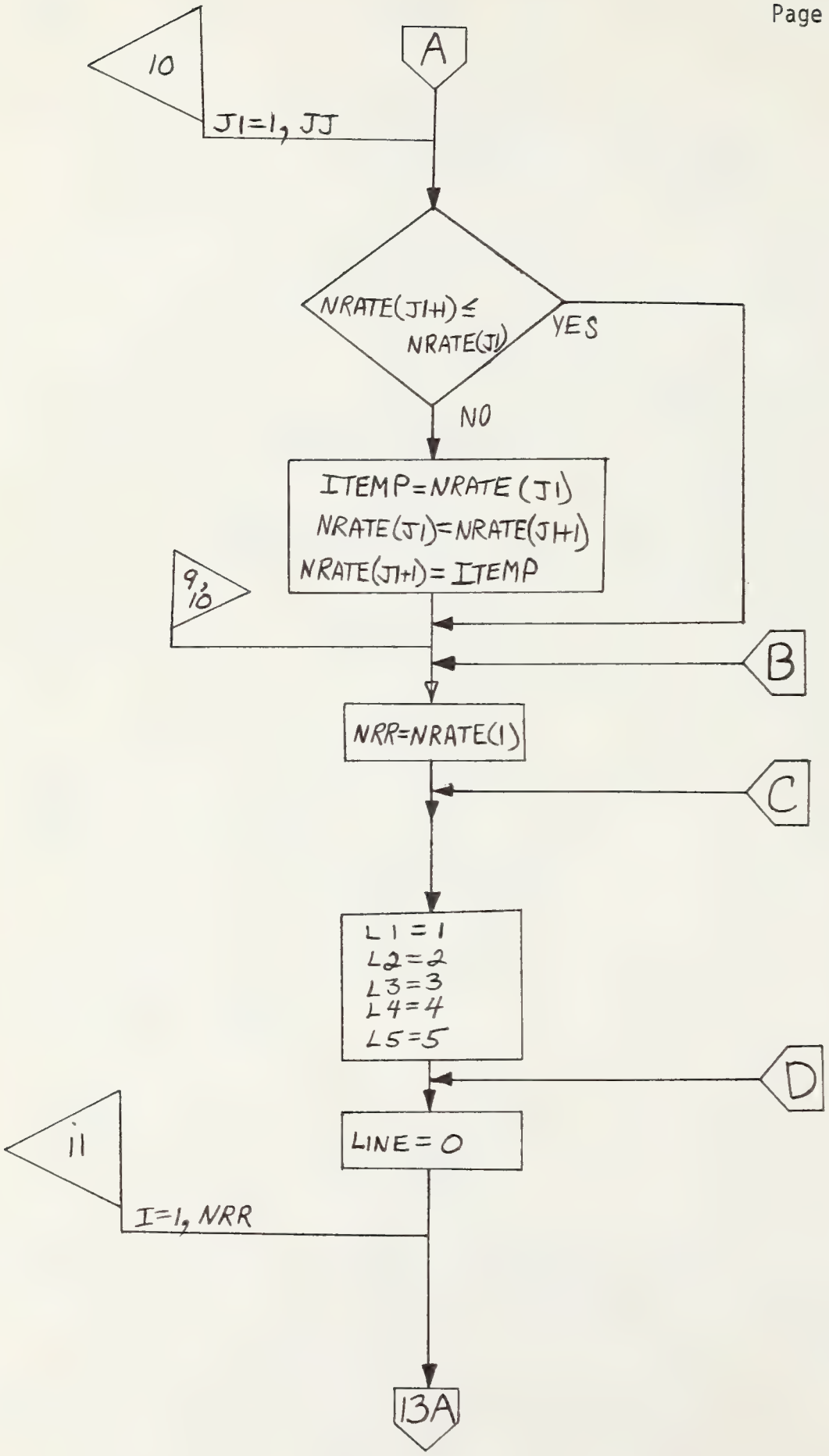

A
IRT=I
NRATE(L)=IRT
XRATE(L,IRT)=RATE(IRT)
VALIN(L,IRT) ≤0.01
AND
VALIN(L,IRT) ≥-0.01
NO
11
B
YES
VALIN(L,IRT)=0.0
NRATE(L)=1
NO
11
B
YES
11C
B
PH=1.00
PL=-1.00
8A

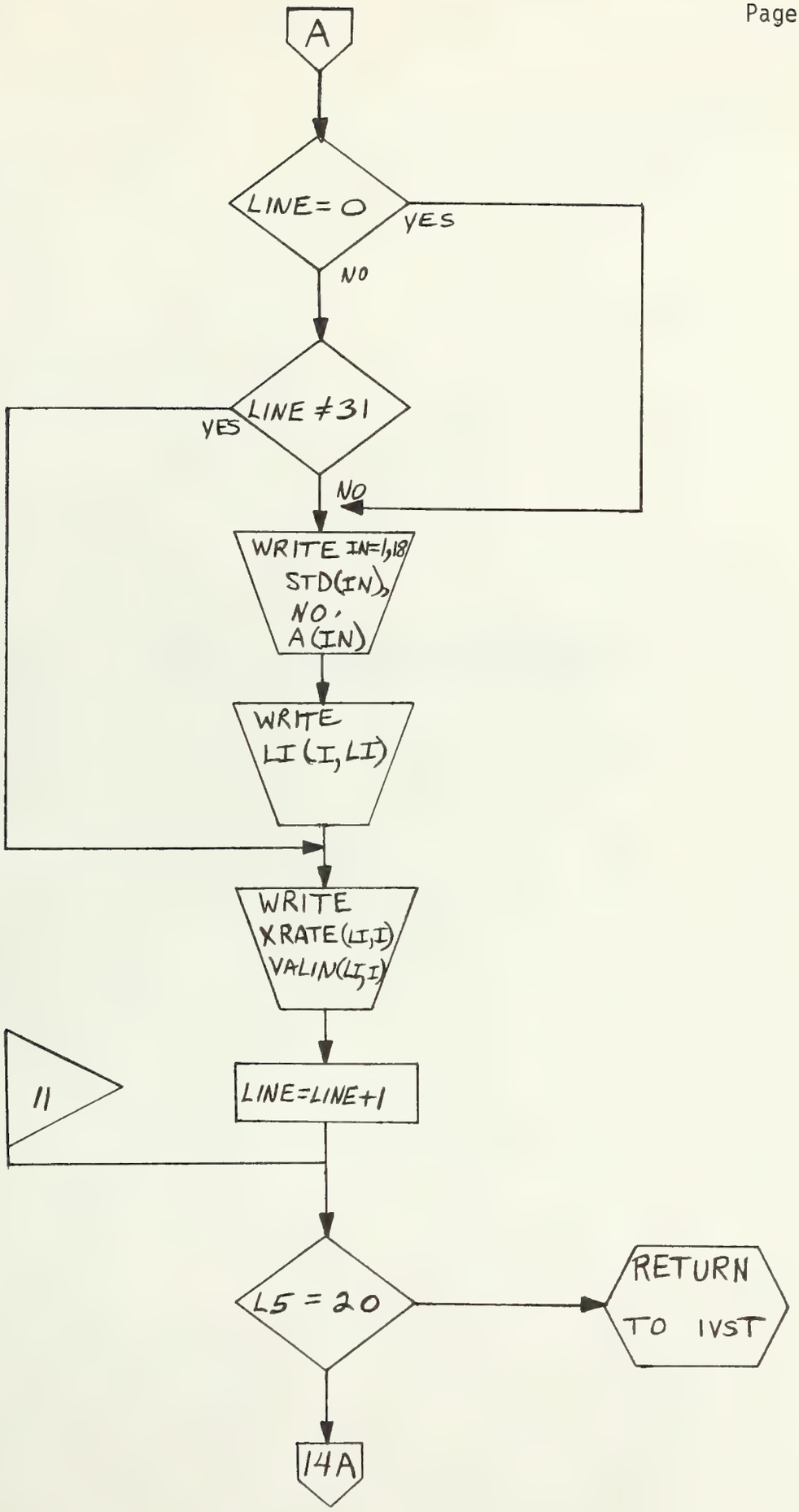

A
IRT=I
Y(1)=VALIN(L,IRT)
Y(2)=VALIN(L,IRT-1)
X(1)=RATE(IRT)
X(2)=RATE(IRT-1)
6
II=3, 100
X(II-2)=X(II-1)
YES
10
B
NO
X(II)=(X(II-2)+X(II-1))/2.0
RLOG=ALOG(1.0+X(II))
DISCO=EXP(RLOG*XLY)
DKC=0.0
DKI=0.0
7
KC=1, KCXA
DKC=DKC+PECO(L,KC)/EXP(RLOG*YR(L,KC))
DKI=DKI+RETURN(L,KC)/EXP(RLOG*YR(L,KC))
7
9A

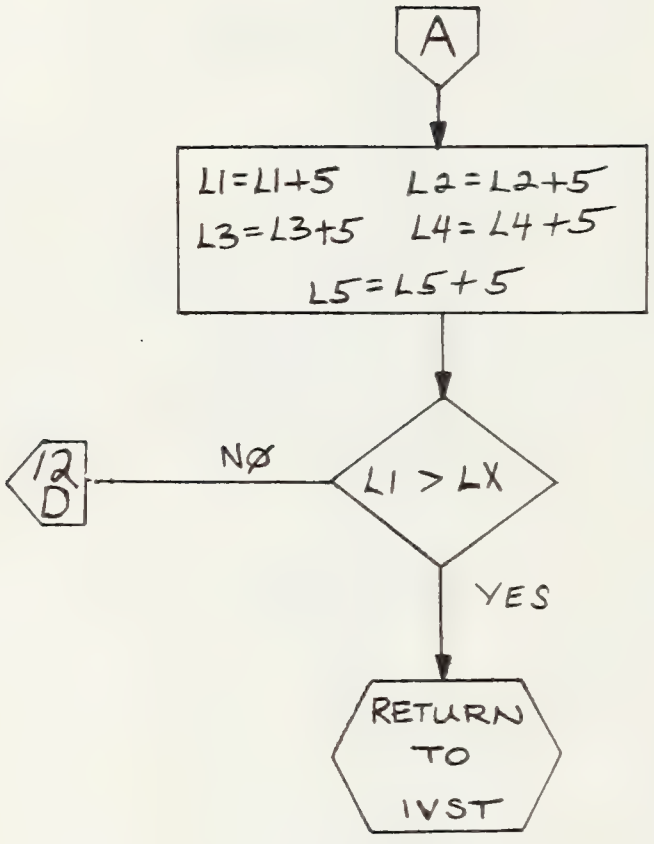

A
TDVAL = DK1 - DKC
NZ = 2
NO
Y(II) = TDVAL * (1.0 + 1.0 / (DISCO - 1.0))
YES
Y(II) = TDVAL
Y(II) ≤ PH
AND
Y(II) ≥ PL
YES
10 C
NO
Y(II)
>0
10A
=0
10 C
<0
Y(II-1) > 0.0
YES
10 B
NO
B
Y(II-1) = Y(II-2)
X(II-1) = X(II-2)
10 B


A
Y(II-1)<0.0
NO
9
B
YES
6
B
LINE<37
NO
WRITE IN=1,18
STD(IN),
NØ,
A(IN)
YES
LINE=0
LINE=LINE+2
WRITE
LI(1,L)
LI(2,L)
PH
VALIN(L,IRT)=Y(II)
PH=PH*10.0
PL=PL*10.0
C
PH>100.00
NO
8
A
YES
VALIN(L,IRT)=PH
NRATE(L)=IRT
11A


A
XRATE(L,IRT) = X(II)
B
NRT = NRATE(L) - 1
8
JIM = 1, NRT
KK = NRATE(L) - JIM
8
XRATE(L,KK) = RATE(KK)
2
C
LX = 1
YES
12
B
NO
LR ≠ 1
NØ
NRR = NR
YES
12
C
KM = LX - 1
9
I1 = 1, KM
JJ = LX - I1
12A


10
J1=1, JJ
A
NRATE(J1+1) ≤ NRATE(J1)
YES
NO
ITEMP=NRATE(J1)
NRATE(J1)=NRATE(J1+1)
NRATE(J1+1)=ITEMP
9, 10
B
NRR=NRATE(1)
C
L1=1
L2=2
L3=3
L4=4
L5=5
D
11
I=1, NRR
LINE=0
13A


A
LINE=0
YES
NO
LINE≠31
YES
NO
WRITE IN=1,18
STD(IN),
NO,
A(IN)
WRITE
LI(I,LI)
WRITE
XRATE(LI,I)
VALIN(LI,I)
11
LINE=LINE+1
L5=20
RETURN
TO IVST
14A


A
L1=L1+5 L2=L2+5
L3=L3+5 L4=L4+5
L5=L5+5
L1 > LX
NØ
12
D
YES
RETURN
TO
IVST

IVST SOURCE PROGRAM

```
C INVESTMENT ANALYSIS PROGRAM                                                  IVST0000
C PROGRAM IVST                                    MAY 1968                     IVST0005
C BY D.E. CHAPPELLE                                                            IVST0010
C PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION                        IVST0015
C                                                                              IVST0020
C MAIN PROGRAM TO CALL IROR AND BCA SUBROUTINES                                IVST0025
C                                                                              IVST0030
C                                                                              IVST0035
C                                                                              IVST0040
C                                                                              IVST0045
C                                    SYMBOL TABLE                              IVST0050
C     A(I)=ALPHANUMERIC PROBLEM IDENTIFICATION (1-72 CHARACTERS)               IVST0055
C     BRATE=BEGINNING INTEREST RATE (MUST BE GREATER THAN -100 PERCENT),       IVST0060
C          DECIMAL                                                             IVST0065
C     COST(L,KC)=PERIODIC ANNUAL COST OF ALTERNATIVE L, FOR PERIOD KC,         IVST0070
C                DOLLARS.                                                      IVST0075
C     DELTA=RATE INCREMENT, DECIMAL                                            IVST0080
C     FRATE=FINAL INTEREST RATE, DECIMAL                                       IVST0085
C     INIT=INITIAL VALUE CODE                                                  IVST0086
C         =0, IF THERE IS AN INITIAL COST OR RETURN                            IVST0087
C         =1, IF NOT                                                           IVST0088
C     NOTE--WHEN INIT=0, IP MUST EQUAL 1                                       IVST0089
C     INVESTMENT CRITERION                                                     IVST0090
C         IC=01, INTERNAL RATE OF RETURN                                       IVST0095
C         IC=02, BENEFIT/COST AND PRESENT NET WORTH                            IVST0100
C         IC=03, ALL THREE CRITERIA                                            IVST0105
C     IP=LENGTH OF PERIOD OVER WHICH ONE COST OR RETURN APPLIES,               IVST0110
C        YEARS (1-140). PERIOD MUST BE THE SAME FOR ALL ALTERNATIVES           IVST0115
C        WITHIN A PROBLEM.                                                     IVST0120
C     KCT=NUMBER OF PERIODS (1-140)                                            IVST0125
C     KCX(L)=NUMBER OF YEARS IN EACH ALTERNATIVE L (1-140)                     IVST0130
C     KCXX=MAXIMUM NUMBER OF YEARS IN ANY ALTERNATIVE (1-140)                  IVST0135
C     LI(1,L), LI(2,L)=ALPHANUMERIC IDENTIFICATION OF ALTERNATIVE L            IVST0140
C          (1-8 CHARACTERS)                                                    IVST0145
C     LX=NUMBER OF ALTERNATIVES WITHIN PROBLEM (1-20)                          IVST0150
C     MEND=TERMINAL CARD CODE---98, TO DO ANOTHER PROBLEM                      IVST0155
C                              99, END-OF-RUN                                  IVST0160
C                                                                              IVST0165
C     NO=PROBLEM NUMBER                                                        IVST0170
C     REV(L,KC)=PERIODIC ANNUAL VALUE YIELD OF PRODUCT IN ALTERNATIVE L,       IVST0175
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C                FOR PERIOD KC, DOLLARS.                                    IVST0180
C     STD(I)=ALPHANUMERIC STUDY IDENTIFICATION (1-72 CHARACTERS)            IVST0185
C     TYPE OF CALCULATION-                                                  IVST0190
C          NZ=01, IF PERPETUAL SERIES.                                      IVST0195
C          NZ=02, IF TERMINABLE SERIES.                                     IVST0200
C          TYPE OF CALCULATION MUST BE THE SAME FOR ALL ALTERNATIVES        IVST0205
C          WITHIN A PROBLEM.                                                IVST0210
C     YR(L,LZ)=YEAR IN WHICH LTH COST AND RETURN OCCURS (1-140).            IVST0215
C                                                                           IVST0220
C                                                                           IVST0225
C                                                                           IVST0230
C                                                                           IVST0235
      INTEGER COST(20,140), REV(20,140)                                     IVST0240
      DIMENSION KCX(20),RTLOG(200),PECO(20,140),RETURN(20,140),LI(2,20),IVST0245
     1A(18),STD(18),YR(20,140),RATE(200)                                    IVST0250
     2,BCR(20,200),VALIN(20,200)                                            IVST0255
      COMMON KCX,RTLOG,PECO,RETURN,LI,A,STD,YR,NZ,RATE,NR,LX,BCR,VALIN,     IVST0260
     1NO,FRATE                                                              IVST0265
C                                                                           IVST0270
C  INPUT FORMATS                                                            IVST0275
C                                                                           IVST0280
  100 FORMAT (3F10.2,2I5)                                                   IVST0285
  105 FORMAT (10(2A4))                                                      IVST0290
  110 FORMAT (20I3)                                                         IVST0295
  115 FORMAT (5I4)                                                          IVST0300
  120 FORMAT (I3)                                                           IVST0305
  125 FORMAT (8I10)                                                         IVST0310
  130 FORMAT (18A4)                                                         IVST0315
C                                                                           IVST0320
C  OUTPUT FORMATS                                                           IVST0325
C                                                                           IVST0330
  135 FORMAT (1H1,19X,21HINVESTMENT ANALYSIS--,18A4/1H0,11HPROBLEM NO.,     IVST0335
     1I3,6X,18A4)                                                           IVST0340
  140 FORMAT (1H0, 17HTERMINABLE SERIES,85X,8HPERIOD= ,I3,6H YEARS)         IVST0345
  145 FORMAT (1H ,52X,22HMANAGEMENT ALTERNATIVE)                            IVST0350
  150 FORMAT (1H0,16HPERPETUAL SERIES,84X,8HPERIOD= ,I4,6H YEARS)           IVST0355
  155 FORMAT(1H0,60X,10HEND OF RUN)                                         IVST0360
  160 FORMAT(1H0,3X,6HPERIOD,2X,5(6HANNUAL,5X,6HANNUAL,7X)/13X,4(4HCOST,    IVST0365
     16X,6HRETURN,8X),4HCOST,6X,6HRETURN)                                   IVST0370
  165 FORMAT (1H ,16X,2A4,4(16X,2A4))                                       IVST0375
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```
  170 FORMAT (1H ,3X,I3,5(1X,I10,1X,I10,2X))                          IVST0380
C                                                                     IVST0385
C READ STUDY IDENTIFICATION CARD                                      IVST0390
C                                                                     IVST0395
      READ (5,130) (STD(I),I=1,18)                                    IVST0400
C                                                                     IVST0405
C READ RATE CARD                                                      IVST0410
C                                                                     IVST0415
  175 READ (5,100) BRATE,FRATE,DELTA,LX,INIT                          IVST0420
C                                                                     IVST0425
C  READ PROBLEM NO. AND ALTERNATIVE TITLE CARDS                       IVST0430
C                                                                     IVST0435
      READ (5,105) ((LI(I,L),I=1,2),L=1,LX)                           IVST0440
      READ (5,115) NO,NZ,IC,IP,KCXX                                   IVST0445
      READ (5,110) (KCX(L),L=1,LX)                                    IVST0450
      KCT=KCXX/IP                                                     IVST0455
      DO 180 L=1,LX                                                   IVST0460
      DO 180 KC=1,KCT                                                 IVST0465
      COST(L,KC) = 0                                                  IVST0470
      REV(L,KC) = 0                                                   IVST0475
  180 CONTINUE                                                        IVST0480
      IF(BRATE.NE.0.0.AND.FRATE.NE.0.0) GO TO 185                     IVST0485
      IF(NZ.EQ.2) GO TO 185                                           IVST0490
      IF(BRATE.EQ.0.0) BRATE=BRATE+DELTA                              IVST0495
      IF(FRATE.EQ.0.0) FRATE=FRATE-DELTA                              IVST0500
C                                                                     IVST0505
C  CALCULATE NUMBER RATES (NR), RATE(I),I=1,NR) AND                   IVST0510
C                  LOG(1.+RATE(I) WHICH IS RTLOG(I) IN PROGRAM        IVST0515
C                                                                     IVST0520
  185 NR=((FRATE-BRATE)/DELTA)+1.05                                   IVST0525
      RATE(1)=BRATE                                                   IVST0530
      RTLOG(1)=ALOG(1.0+RATE(1))                                      IVST0535
      DO 195 I=2,NR                                                   IVST0540
      RATE(I)=RATE(I-1)+DELTA                                         IVST0545
      IF(RATE(I).NE.0.0)   GO TO 190                                  IVST0550
      IF(NZ.EQ.2) GO TO 190                                           IVST0555
      RATE(I)=RATE(I)+DELTA                                           IVST0560
  190 RTLOG(I)=ALOG(1.0+RATE(I))                                      IVST0565
  195 CONTINUE                                                        IVST0570
C                                                                     IVST0575
```

```
C  READ PROBLEM IDENTIFICATION CARD                                          IVST0580
C                                                                           IVST0585
      READ(5,130)(A(I),I=1,18)                                              IVST0590
C                                                                           IVST0595
C  READ PERIODIC ANNUAL COSTS AND RETURNS                                   IVST0600
C                                                                           IVST0605
      DO 200 L=1,LX                                                         IVST0610
      KCS = KCX(L)/IP                                                       IVST0615
      READ (5,125) (COST(L,KC),KC=1,KCS)                                    IVST0620
      READ (5,125) (REV(L,KC),KC=1,KCS)                                     IVST0625
  200 CONTINUE                                                              IVST0630
C                                                                           IVST0635
C  WRITE PERIODIC ANNUAL COSTS AND RETURNS                                  IVST0640
C                                                                           IVST0645
      L1=1                                                                  IVST0650
      L2=2                                                                  IVST0655
      L3=3                                                                  IVST0660
      L4=4                                                                  IVST0665
      L5=5                                                                  IVST0670
  205 LINE=0                                                                IVST0675
  210 DO 245  K=1,KCT                                                       IVST0680
  215 IF(LINE.NE.0) GO TO 235                                               IVST0685
  220 WRITE (6,135) (STD(I),I=1,18),NO,(A(I),I=1,18)                        IVST0690
      IF (NZ.EQ.1) GO TO 225                                                IVST0695
      WRITE (6,140) IP                                                      IVST0700
      GO TO 230                                                             IVST0705
  225 WRITE (6,150) IP                                                      IVST0710
  230 WRITE (6,145)                                                         IVST0715
      WRITE (6,165) LI(1,L1),LI(2,L1),LI(1,L2),LI(2,L2),LI(1,L3),LI(2,L3IVST0720
     1),LI(1,L4),LI(2,L4),LI(1,L5),LI(2,L5)                                 IVST0725
      WRITE (6,160)                                                         IVST0730
  235 KC=K                                                                  IVST0731
      KT=K                                                                  IVST0732
      IF(IP.EQ.1.AND.INIT.EQ.0) KT=K-1                                      IVST0733
      WRITE (6,170) KT,COST(L1,KC),REV(L1,KC),COST(L2,KC),REV(L2,KC),COSIVST0735
     1T(L3,KC),REV(L3,KC),COST(L4,KC),REV(L4,KC),COST(L5,KC),REV(L5,KC) IVST0740
  240 LINE=LINE+1                                                           IVST0745
      IF (LINE.EQ.31) LINE=0                                                IVST0750
  245 CONTINUE                                                              IVST0755
      IF (L5.EQ.20) GO TO 250                                               IVST0760
```

```
      L1=L1+5                                                          IVST0765
      L2=L2+5                                                          IVST0770
      L3=L3+5                                                          IVST0775
      L4=L4+5                                                          IVST0780
      L5=L5+5                                                          IVST0785
      IF (L1.GT.LX) GO TO 250                                          IVST0790
      GO TO 205                                                        IVST0795
C                                                                      IVST0800
C  GENERATE ANNUAL COSTS AND RETURNS                                   IVST0805
C                                                                      IVST0810
  250 DO 265 L=1,LX                                                    IVST0815
      LZ=0                                                             IVST0820
      DO 260 KC=1,KCT                                                  IVST0825
      LXX=0                                                            IVST0830
  255 LZ=LZ+1                                                          IVST0835
      PECO(L,LZ)=COST(L,KC)                                            IVST0840
      RETURN(L,LZ)=REV(L,KC)                                           IVST0845
      YR(L,LZ)=LZ                                                      IVST0850
      IF(IP.EQ.1.AND.INIT.EQ.0) YR(L,LZ)=YR(L,LZ)-1.0                  IVST0851
      LXX=LXX+1                                                        IVST0855
      IF (LXX.LT.IP) GO TO 255                                         IVST0860
  260 CONTINUE                                                         IVST0865
  265 CONTINUE                                                         IVST0870
C                                                                      IVST0875
C                                                                      IVST0880
C  CALL INVESTMENT CRITERION                                           IVST0885
      IF (IC.EQ.03.OR.IC.EQ.02) CALL BCA                               IVST0890
      IF (IC.EQ.03.OR.IC.EQ.01) CALL IROR                              IVST0895
C                                                                      IVST0900
C  READ TERMINAL CARD                                                  IVST0905
C                                                                      IVST0910
  270 READ(5,120) MEND                                                 IVST0915
      IF(MEND.EQ.99) GO TO 275                                         IVST0920
      GO TO 175                                                        IVST0925
  275 WRITE(6,155)                                                     IVST0930
      STOP                                                             IVST0935
      END                                                              IVST0940
```

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C BENEFIT/COST AND PRESENT NET WORTH ANALYSIS                                    BCA 0000
C SUBROUTINE BCA                                MAY 1968                        BCA 0005
C BY D.E. CHAPPELLE                                                             BCA 0010
C PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION                         BCA 0015
C                                                                               BCA 0020
C CALLED BY PROGRAM IVST                                                        BCA 0025
      SUBROUTINE BCA                                                            BCA 0030
      DIMENSION KCX(20),YR(20,140),BCR(20,200),RATE(200),                       BCA 0035
     1RTLOG(200),PECO(20,140),RETURN(20,140),LI(2,20),                          BCA 0040
     2A(18), VALIN(20,200),STD(18)                                              BCA 0045
      COMMON KCX,RTLOG,PECO,RETURN,LI,A,STD,YR,NZ,RATE,NR,LX,BCR,VALIN,         BCA 0050
     1NO,FRATE                                                                  BCA 0055
C                                                                               BCA 0060
C OUTPUT FORMATS                                                                BCA 0065
C                                                                               BCA 0070
  100 FORMAT (1H1)                                                              BCA 0075
  105 FORMAT (1H1,19X,23HBENEFIT-COST ANALYSIS--,18A4,/1HO,11HPROBLEM NOBCA 0080
     1.,I3,6X,18A4)                                                             BCA 0085
  110 FORMAT (1HO,52X,22HMANAGEMENT ALTERNATIVE)                                BCA 0090
  115 FORMAT (1HO,57HBENEFIT-COST RATIO (B/C) AT ALTERNATIVE RATES OF INBCA 0095
     1TEREST,/,1H ,56HPRESENT NET WORTH (PNW) AT ALTERNATIVE RATES OF INBCA 0100
     2TEREST)                                                                   BCA 0105
  120 FORMAT (1H ,21X,2A4,4(15X,2A4),/,1HO,2X,4HRATE,10X,4H*PNW,8X,4HB/CBCA 0110
     1*,4(8X,4H*PNW,8X,4HB/C*),//)                                              BCA 0115
  125 FORMAT (2PF7.2,4X,0PE13.4,F9.2,4(2X,E13.4,F9.2))                          BCA 0120
C                                                                               BCA 0125
      WRITE (6,100)                                                             BCA 0130
C                                                                               BCA 0135
C CLEAR ARRAY FOR  PRESENT NET WORTH (VALIN(L,I)) AND BENEFIT-COST              BCA 0140
C RATIO (BCR(L,I)) ARRAY                                                        BCA 0145
C                                                                               BCA 0150
      DO 130 LLL=1,LX                                                           BCA 0155
      DO 130 III=1,NR                                                           BCA 0160
      VALIN(LLL,III) = 0.0                                                      BCA 0165
      BCR(LLL,III)=0.0                                                          BCA 0170
  130 CONTINUE                                                                  BCA 0175
C                                                                               BCA 0180
C  BEGINNING OF L-LOOP (ALTERNATIVES)                                           BCA 0185
C                                                                               BCA 0190
```

```
      DO 175 L=1,LX                                                    BCA 0195
      KCXA=KCX(L)                                                      BCA 0200
      XLY=FLOAT(KCX(L))                                                BCA 0205
      IF (KCXA.EQ.0) GO TO 175                                         BCA 0210
C                                                                      BCA 0215
C  BEGINNING I-LOOP (RATES OF RETURN)                                  BCA 0220
C                                                                      BCA 0225
  135 DO 175 I=1,NR                                                    BCA 0230
      DKC=0.0                                                          BCA 0235
      DK1=0.0                                                          BCA 0240
      IF(RTLOG(I).EQ.0.0) GO TO 145                                    BCA 0245
C                                                                      BCA 0250
C  CALCULATE DISCOUNTED COST AND RETURN                                BCA 0255
C                                                                      BCA 0260
      DO 140 KC=1,KCXA                                                 BCA 0265
      DKC=DKC+PECO(L,KC)/EXP(RTLOG(I)*YR(L,KC))                        BCA 0270
      DK1=DK1+RETURN(L,KC)/EXP(RTLOG(I)*YR(L,KC))                      BCA 0275
  140 CONTINUE                                                         BCA 0280
      GO TO 155                                                        BCA 0285
  145 DO 150 KC=1,KCXA                                                 BCA 0290
      DKC=DKC+PECO(L,KC)                                               BCA 0295
      DK1=DK1+RETURN(L,KC)                                             BCA 0300
  150 CONTINUE                                                         BCA 0305
C                                                                      BCA 0310
C CALCULATE PRESENT NET WORTH (VALIN) AND BENEFIT-COST RATIO (B/C)     BCA 0315
C                                                                      BCA 0320
  155 IF (NZ.EQ.2) GO TO 160                                           BCA 0325
      DISCO=EXP(RTLOG(I)*XLY)                                          BCA 0330
      DIS=(1.0+1.0/(DISCO-1.0))                                        BCA 0335
      DK1=DK1*DIS                                                      BCA 0340
      DKC=DKC*DIS                                                      BCA 0345
  160 VALIN(L,I) = DK1 - DKC                                           BCA 0350
C                                                                      BCA 0355
C  IF USER DESIRES TO PRINT DISCOUNTED RETURNS AND COSTS, REMOVE THE C BCA 0360
C  FROM COLUMN 1 OF THE NEXT 2 CARDS                                   BCA 0365
C     WRITE(6,162) DK1,DKC                                             BCA 0370
C 162 FORMAT (1H ,E15.4,10X,E15.4)                                     BCA 0375
      IF (DK1.EQ.0.0.OR.DKC.EQ.0.0) GO TO 170                          BCA 0380
      IF (DK1.GT.0.0) GO TO 165                                        BCA 0385
      IF (DKC.GT.0.0) GO TO 170                                        BCA 0390
```

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      BCR(L,I) = DKC / DK1                                                    BCA 0395
      GO TO 175                                                               BCA 0400
  165 IF (DKC.LT.0.0) GO TO 170                                               BCA 0405
      BCR(L,I) = DK1 / DKC                                                    BCA 0410
      GO TO 175                                                               BCA 0415
  170 BCR(L,I) = 0.0                                                          BCA 0420
  175 CONTINUE                                                                BCA 0425
C                                                                             BCA 0430
C  END OF I-LOOP                                                            BCA 0435
C  END OF L-LOOP                                                            BCA 0440
C                                                                             BCA 0445
C WRITE BENEFIT-COST RATIO                                                    BCA 0450
C                                                                             BCA 0455
      L1=1                                                                    BCA 0460
      L2=2                                                                    BCA 0465
      L3=3                                                                    BCA 0470
      L4=4                                                                    BCA 0475
      L5=5                                                                    BCA 0480
  180 LINE=0                                                                  BCA 0485
      DO 195 I=1,NR                                                           BCA 0490
      IF(LINE.EQ.0) GO TO 185                                                 BCA 0495
      IF (LINE.NE.31) GO TO 190                                               BCA 0500
  185 WRITE (6,105) (STD(IN),IN=1,18), NO, (A(IN),IN=1,18)                    BCA 0505
      WRITE (6,115)                                                           BCA 0510
      WRITE (6,110)                                                           BCA 0515
      WRITE (6,120) LI(1,L1),LI(2,L1),LI(1,L2),LI(2,L2),LI(1,L3),LI(2,L3BCA 0520
     1),LI(1,L4),LI(2,L4),LI(1,L5),LI(2,L5)                                   BCA 0525
  190 WRITE (6,125) RATE(I),VALIN(L1,I),BCR(L1,I),VALIN(L2,I),BCR(L2,I),BCA 0530
     1VALIN(L3,I),BCR(L3,I),VALIN(L4,I),BCR(L4,I),VALIN(L5,I),BCR(L5,I)       BCA 0535
      LINE=LINE+1                                                             BCA 0540
  195 CONTINUE                                                                BCA 0545
      IF(L5.EQ.20) RETURN                                                     BCA 0550
      L1=L1+5                                                                 BCA 0555
      L2=L2+5                                                                 BCA 0560
      L3=L3+5                                                                 BCA 0565
      L4=L4+5                                                                 BCA 0570
      L5=L5+5                                                                 BCA 0575
      IF (L1.GT.LX) RETURN                                                    BCA 0580
      GO TO 180                                                               BCA 0585
      END                                                                     BCA 0590
```

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700

C DETERMINING RATE OF RETURN                                                    IRORO000
C SUBROUTINE IROR                              MAY 1968                         IRORO005
C BY D.E. CHAPPELLE                                                             IRORO010
C PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION                         IRORO015
C                                                                               IRORO020
C CALLED BY PROGRAM IVST                                                        IRORO025
C                                                                               IRORO030
C (BASED ON SOUTHERN FOREST EXPERIMENT STATION INVESTMENT ANALYSIS              IRORO035
C PROGRAM BY CLARK ROW)                                                         IRORO040
C                                                                               IRORO045
C BISECTION METHOD IS USED TO DETERMINE RATE AT WHICH DISCOUNTED NET            IRORO050
C WORTH APPROACHES 0.0                                                          IRORO055
C                                                                               IRORO060
C PRECISION LEVELS ARE VARIED WITHIN THE BISECTION ANALYSIS                     IRORO065
C                                                                               IRORO070
C THE PRECISION APPLICABLE TO THE CALCULATED RATE OF RETURN IS SHOWN            IRORO075
C AS THE LAST ENTRY IN THE PRESENT NET WORTH COLUMN                             IRORO080
C                                                                               IRORO085
      SUBROUTINE IROR                                                           IRORO090
      DIMENSION KCX(20),YR(20,140),VALIN(20,200),X(100),Y(100),NRATE(20)IRORO095
     1,RATE(200),RTLOG(200),PECO(20,140),RETURN(20,140),LI(2,20),               IRORO100
     2A(18),STD(18)                                                             IRORO105
      COMMON KCX,RTLOG,PECO,RETURN,LI,A,STD,YR,NZ,RATE,NR,LX,XRATE(20,20IRORO110
     10),VALIN,NO,FRATE                                                         IRORO115
C                                                                               IRORO120
C  OUTPUT FORMATS                                                               IRORO125
C                                                                               IRORO130
  100 FORMAT (1HO,10X,39HBISECTION LIMIT EXCEEDED IN ALTERNATIVE,2A4/1H IRORO135
     1,10X,66HCALCULATED PRESENT NET WORTH DOES NOT FALL BETWEEN PLUS ANIRORO140
     2D MINUS ,F6.2,8H DOLLARS,/)                                               IRORO145
  105 FORMAT (1H1,19X,28HDETERMINING RATE OF RETURN--,18A4/1HO,11HPROBLEIRORO150
     1M NO.,I3,6X,18A4)                                                         IRORO155
  110 FORMAT (1HO,50X,8HMESSAGES,/)                                             IRORO160
  115 FORMAT (1HO,52X,22HMANAGEMENT ALTERNATIVE,/)                              IRORO165
  120 FORMAT(1HO,56HPRESENT NET WORTH (PNW) AT ALTERNATIVE RATES OF INTEIRORO170
     1REST)                                                                     IRORO175
  125 FORMAT (1H ,5X,2A4,4(20X,2A4)/1HO,4(7H * RATE,7X,5HPNW *,8X),7H * IRORO180
     1RATE,7X,5HPNW *,//)                                                       IRORO185
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  130 FORMAT (4(2PF7.2,1PE13.4,7X),2PF7.2,1PE13.4)                        IROR0190
  135 FORMAT (1H ,10X,76HINTERNAL RATE OF RETURN DOES NOT FALL WITHIN SEIROR0195
     1LECTED RANGE FOR ALTERNATIVE ,I3)                                   IROR0200
  140 FORMAT(1H ,10X,108HPNW AS A FUNCTION OF INTEREST RATE IS NOT TENDIIROR0205
     1NG TOWARD ZERO WITHIN A PORTION OF ITS RANGE FOR ALTERNATIVE ,I3) IROR0210
C                                                                         IROR0215
      WRITE (6,105) (STD(IN),IN=1,18),NO,(A(IN),IN=1,18)                  IROR0220
      LINE=0                                                              IROR0225
      WRITE (6,110)                                                       IROR0230
C                                                                         IROR0235
C  CLEAR ARRAY FOR DISCOUNTED NET WORTH(VALIN(L,I) AND XRATE ARRAY        IROR0240
C                                                                         IROR0245
      DO 145 LLL=1,LX                                                     IROR0250
      DO 145 III=1,NR                                                     IROR0255
      VALIN(LLL,III)=0.0                                                  IROR0260
  145 XRATE(LLL,III)=0.0                                                  IROR0265
C  BEGINNING OF L-LOOP (ALTERNATIVES)                                     IROR0270
C                                                                         IROR0275
      DO 305 L=1,LX                                                       IROR0280
      KCXA=KCX(L)                                                         IROR0285
      XLY = FLOAT(KCX(L))                                                 IROR0290
      IF(KCXA.EQ.0) GO TO 305                                             IROR0295
C                                                                         IROR0300
C  BEGINNING I-LOOP (RATES OF RETURN)                                     IROR0305
C                                                                         IROR0310
  150 DO 210 I=1,NR                                                       IROR0315
      DKC=0.0                                                             IROR0320
      DK1=0.0                                                             IROR0325
      IF(RTLOG(I).EQ.0.0) GO TO 195                                       IROR0330
C                                                                         IROR0335
C  CALCULATE DISCOUNTED COST AND RETURN                                   IROR0340
C                                                                         IROR0345
      DO 155 KC=1,KCXA                                                    IROR0350
      DKC=DKC+PECO(L,KC)/EXP(RTLOG(I)*YR(L,KC))                           IROR0355
      DK1=DK1+RETURN(L,KC)/EXP(RTLOG(I)*YR(L,KC))                         IROR0360
  155 CONTINUE                                                            IROR0365
C                                                                         IROR0370
C  TOTAL DISCOUNTED VALUE (TDVAL)                                         IROR0375
```

```
C                                                                       IRORO380
  160 TDVAL=DK1-DKC                                                     IRORO385
      IF(NZ.EQ.2) GO TO 190                                             IRORO390
C                                                                       IRORO395
C  PRESENT NET WORTH (VALIN)                                            IRORO400
C                                                                       IRORO405
      DISCO=EXP(RTLOG(I)*XLY)                                           IRORO410
      VALIN(L,I)=TDVAL*(1.0+1.0/(DISCO-1.0))                            IRORO415
  165 IF(VALIN(L,I).LE.0.01.AND.VALIN(L,I).GE.(-0.01)) GO TO 225        IRORO420
      IF(I.EQ.1) GO TO 210                                              IRORO425
      IF(VALIN(L,I-1))170,225,180                                       IRORO430
  170 IF(VALIN(L,I).GT.0.0) GO TO 235                                   IRORO435
      IF(VALIN(L,I).GE.VALIN(L,I-1)) GO TO 210                          IRORO440
      IF (LINE.LT.37) GO TO 175                                         IRORO445
      WRITE (6,105) (STD(IN),IN=1,18),NO,(A(IN),IN=1,18)                IRORO450
      LINE=0                                                            IRORO455
  175 LINE=LINE+1                                                       IRORO460
      WRITE (6,140) L                                                   IRORO465
      GO TO 225                                                         IRORO470
  180 IF(VALIN(L,I).LT.0.0)GO TO 235                                    IRORO475
      IF(VALIN(L,I).LE.VALIN(L,I-1)) GO TO 210                          IRORO480
      IF (LINE.LT.37) GO TO 185                                         IRORO485
      WRITE (6,105) (STD(IN),IN=1,18),NO,(A(IN),IN=1,18)                IRORO490
      LINE=0                                                            IRORO495
  185 LINE=LINE+1                                                       IRORO500
      WRITE (6,140) L                                                   IRORO505
      GO TO 225                                                         IRORO510
  190 VALIN(L,I)=TDVAL                                                  IRORO515
      GO TO 165                                                         IRORO520
  195 DO 200 KC=1,KCXA                                                  IRORO525
      DKC=DKC+PECO(L,KC)                                                IRORO530
      DK1=DK1+RETURN(L,KC)                                              IRORO535
  200 CONTINUE                                                          IRORO540
  205 VALIN(L,I)=DK1-DKC                                                IRORO545
      GO TO 165                                                         IRORO550
  210 CONTINUE                                                          IRORO555
C                                                                       IRORO560
C  END OF I-LOOP                                                        IRORO565
```

```
C                                                                               IROR0570
  215 IRT=NR                                                                    IROR0575
      NRATE(L)=IRT                                                              IROR0580
      XRATE(L,IRT)=FRATE                                                        IROR0585
      LR = 1                                                                    IROR0590
      IF (LINE.LT.37) GO TO 220                                                 IROR0595
      WRITE (6,105) (STD(IN),IN=1,18),NO,(A(IN),IN=1,18)                        IROR0600
      LINE=0                                                                    IROR0605
  220 LINE=LINE+1                                                               IROR0610
      WRITE (6,135) L                                                           IROR0615
      GO TO 295                                                                 IROR0620
  225 IRT=I                                                                     IROR0625
      NRATE(L)=IRT                                                              IROR0630
      XRATE(L,IRT)=RATE(IRT)                                                    IROR0635
      IF(VALIN(L,IRT).LE.0.01.AND.VALIN(L,IRT).GE.(-0.01)) GO TO 230            IROR0640
      GO TO 295                                                                 IROR0645
  230 VALIN(L,IRT)=0.0                                                          IROR0650
      IF(NRATE(L).EQ.1) GO TO 305                                               IROR0655
      GO TO 295                                                                 IROR0660
C                                                                               IROR0665
C  BEGINNING BISECTION COMPUTATION                                              IROR0670
C                                                                               IROR0675
  235 PH=1.00                                                                   IROR0680
      PL=-1.00                                                                  IROR0685
  240 IRT=I                                                                     IROR0690
      Y(1)=VALIN(L,IRT)                                                         IROR0695
      Y(2)=VALIN(L,IRT-1)                                                       IROR0700
      X(1)=RATE(IRT)                                                            IROR0705
      X(2)=RATE(IRT-1)                                                          IROR0710
      DO 275 II=3,100                                                           IROR0715
      IF(X(II-2).EQ.X(II-1)) GO TO 275                                          IROR0720
      X(II)=(X(II-2)+X(II-1))/2.0                                               IROR0725
      RLOG=ALOG(1.0+X(II))                                                      IROR0730
      DISCO=EXP(RLOG*XLY)                                                       IROR0735
      DKC=0.0                                                                   IROR0740
      DK1=0.0                                                                   IROR0745
      DO 245 KC=1,KCXA                                                          IROR0750
      DKC=DKC+PECO(L,KC)/EXP(RLOG*YR(L,KC))                                     IROR0755
      DK1=DK1+RETURN(L,KC)/EXP(RLOG*YR(L,KC))                                   IROR0760
  245 CONTINUE                                                                  IROR0765
```

```
      TDVAL=DK1-DKC                                                    IROR0770
      IF (NZ.EQ.2) GO TO 250                                           IROR0775
      Y(II)=TDVAL*(1.0+1.0/(DISCO-1.0))                                IROR0780
      GO TO 255                                                        IROR0785
  250 Y(II)=TDVAL                                                      IROR0790
  255 IF(Y(II).LE.PH.AND.Y(II).GE.PL) GO TO 285                        IROR0795
      IF(Y(II)) 260,285,270                                            IROR0800
  260 IF(Y(II-1).GT.0.0) GO TO 275                                     IROR0805
  265 Y(II-1)=Y(II-2)                                                  IROR0810
      X(II-1)=X(II-2)                                                  IROR0815
      GO TO 275                                                        IROR0820
  270 IF(Y(II-1).LT.0.0) GO TO 275                                     IROR0825
      GO TO 265                                                        IROR0830
  275 CONTINUE                                                         IROR0835
C                                                                      IROR0840
C  END OF BISECTION                                                    IROR0845
C                                                                      IROR0850
      IF (LINE.LT.37) GO TO 280                                        IROR0855
      WRITE (6,105) (STD(IN),IN=1,18),NO,(A(IN),IN=1,18)               IROR0860
      LINE=0                                                           IROR0865
  280 LINE=LINE+2                                                      IROR0870
      WRITE (6,100) LI(1,L), LI(2,L), PH                               IROR0875
      VALIN(L,IRT)=Y(II)                                               IROR0880
      PH=PH*10.0                                                       IROR0885
      PL=PL*10.0                                                       IROR0890
      IF(PH.GT.100.00) GO TO 290                                       IROR0895
      GO TO 240                                                        IROR0900
  285 VALIN(L,IRT)=PH                                                  IROR0905
  290 NRATE(L)=IRT                                                     IROR0910
      XRATE(L,IRT)=X(II)                                               IROR0915
  295 NRT=NRATE(L)-1                                                   IROR0920
      DO 300 JIM=1,NRT                                                 IROR0925
      KK=NRATE(L)-JIM                                                  IROR0930
  300 XRATE(L,KK)=RATE(KK)                                             IROR0935
  305 CONTINUE                                                         IROR0940
C                                                                      IROR0945
C  END OF L-LOOP                                                       IROR0950
C                                                                      IROR0955
      IF(LX.EQ.1) GO TO 320                                            IROR0960
      IF (LR.NE.1) GO TO 310                                           IROR0965
```

```
      NRR = NR                                                          IROR0970
      GO TO 325                                                         IROR0975
C                                                                       IROR0980
C  SORT TO FIND LARGEST NRATE(L) WHICH DETERMINES LENGTH OF I-LOOP BELOWIROR0985
C                                                                       IROR0990
  310 KM=LX-1                                                           IROR0995
      DO 315 I1=1,KM                                                    IROR1000
      JJ=LX-I1                                                          IROR1005
      DO 315 J1=1,JJ                                                    IROR1010
      IF(NRATE(J1+1).LE.NRATE(J1))GO TO 315                             IROR1015
      ITEMP=NRATE(J1)                                                   IROR1020
      NRATE(J1)=NRATE(J1+1)                                             IROR1025
      NRATE(J1+1)=ITEMP                                                 IROR1030
  315 CONTINUE                                                          IROR1035
  320 NRR=NRATE(1)                                                      IROR1040
C                                                                       IROR1045
C  WRITE RATE OF RETURN                                                 IROR1050
C                                                                       IROR1055
  325 L1=1                                                              IROR1060
      L2=2                                                              IROR1065
      L3=3                                                              IROR1070
      L4=4                                                              IROR1075
      L5=5                                                              IROR1080
  330 LINE=0                                                            IROR1085
      DO 345 I=1,NRR                                                    IROR1090
      IF(LINE.EQ.0) GO TO 335                                           IROR1095
      IF (LINE.NE.31) GO TO 340                                         IROR1100
  335 WRITE (6,105) (STD(IN),IN=1,18), NO, (A(IN),IN=1,18)              IROR1105
      WRITE (6,120)                                                     IROR1110
      WRITE (6,115)                                                     IROR1115
      WRITE (6,125) LI(1,L1),LI(2,L1),LI(1,L2),LI(2,L2),LI(1,L3),LI(2,L3IROR1120
     1),LI(1,L4),LI(2,L4),LI(1,L5),LI(2,L5)                             IROR1125
  340 WRITE (6,130) XRATE(L1,I),VALIN(L1,I),XRATE(L2,I),VALIN(L2,I),XRATIROR1130
     1E(L3,I),VALIN(L3,I),XRATE(L4,I),VALIN(L4,I),XRATE(L5,I),VALIN(L5,IIROR1135
     2)                                                                 IROR1140
      LINE=LINE+1                                                       IROR1145
  345 CONTINUE                                                          IROR1150
      IF (L5.EQ.20) RETURN                                              IROR1155
      L1=L1+5                                                           IROR1160
      L2=L2+5                                                           IROR1165
```

```
      L3=L3+5                                                          IROR1170
      L4=L4+5                                                          IROR1175
      L5=L5+5                                                          IROR1180
      IF (L1.GT.LX) RETURN                                             IROR1185
      GO TO 330                                                        IROR1190
      END                                                              IROR1195
```

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1969. A computer program for evaluating forestry opportunities under three investment criteria. U.S.D.A. Forest Serv. Res. Pap. PNW-78, 64 pp., illus. Pacific Northwest Forest & Range Experiment Station, Portland, Oregon.

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Headquarters for the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is in Portland, Oregon. The Station's mission is to provide the scientific knowledge, technology, and alternatives for management, use, and protection of forest, range, and related environments for present and future generations. The area of research encompasses Alaska, Washington, and Oregon, with some projects including California, Hawaii, the Western States, or the Nation. Project headquarters are at:

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